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AERIAL VIEW OF WASHINGTON NATIONAL AIRPORT

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D. M. BEACH, *Editor*

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STABILIZATION OF GRAVEL RUNWAYS ON WASHINGTON NATIONAL AIRPORT

BY THE DIVISION OF TESTS, PUBLIC ROADS ADMINISTRATION

Reported by HENRY AARON, Associate Highway Engineer and J. A. KELLEY, JR., Assistant Highway Engineer

The Washington National Airport was built under the joint supervision of several Federal agencies. This report covers the participation of the Public Roads Administration in the stabilization of the gravel runways.

The runways, varying in length from 4,200 to 6,875 feet and surfaced with 3½ inches of bituminous concrete on a stabilized gravel base 9 inches thick, are located almost entirely on what was originally shoal water and mud flats along the Virginia shore of the Potomac River. This low area was filled to an elevation of 12 to 16 feet above the normal water level with material consisting of sand, gravel cobbles, silt, and muck pumped by means of hydraulic dredges from borrow pits located in the river on the outskirts of the field. By placing the pipelines of the hydraulic dredges longitudinally along the runways, the granular material was collected in the runway areas and the silt and muck floated off to be deposited by ponding in the intermediate areas between and outside of the runways.

The gravel in the runways was combined with soil from adjacent upland areas to produce a dense, well-graded, stable base course for the bituminous concrete surfacing. The work of stabilization consisted of scarifying the graded gravel runways, removing oversize stone, adding the proper amount of soil, mixing the gravel and soil by means of cultivators, disk harrows, and plows, compacting with rollers, and shaping with motor graders and drags. The desired gradations, physical properties, and densities were obtained by coordinating the construction operations with laboratory tests performed on the materials and the mixtures.

THE LANDING FIELD of the Washington National Airport occupies over 500 of the 720 acres comprising the airport. About 325 acres of the landing area is located in what was originally shoal water and mud flats along the Virginia shore of the Potomac River. This low area was filled to an elevation of 12 to 16 feet above the normal water level with material pumped from the river by means of hydraulic dredges. The remainder of the landing field was brought to grade with dry fill obtained during the grading of the adjacent upland areas.

Preliminary borings disclosed that there was a layer of soft mud varying from 5 to 20 feet in thickness over most of the site. Underlying the mud was a stratified deposit of sand, gravel, cobbles, and silt.[1] In order to obtain as stable a foundation as possible for the runways and to reduce the differential and ultimate settlements likely to occur, the runway areas were trenched to a width of 200 feet and a depth of 12 feet below mean low water or to hard bottom if encountered at less depth.

The excavated trenches were then backfilled with material pumped from borrow pits located in the river on the outskirts of the field.

The material in the borrow pits contained 60 percent of sand and gravel and 40 percent of silt and muck. By placing the pipe lines of the hydraulic dredges longitudinally along the runways, the granular material was collected in the runway areas and the silt and muck floated off to be deposited by ponding in the intermediate areas between and outside of the runways.

The gravel fill was built up to a height of 6 to 8 feet above the final grade of the runways, the additional material serving as a surcharge to hasten consolidation of the newly placed fill material and any compressible material in the foundation below. It served also to furnish gravel for widening the runways and for use in other areas of the airport.

The hydraulic filling was started in December 1938 and completed in December 1939.

STABILIZATION REQUIRED TO PROVIDE UNIFORM SUPPORT FOR PAVEMENT

In October 1939, the Public Roads Administration was requested by the engineering authorities at the Washington National Airport to make a study of the character and quality of the gravel deposited in the runway areas, and to determine what measures should be taken to produce a satisfactory base course for an asphaltic concrete wearing surface. In addition to the four runways, the paving program included taxiways, aprons, access and service roads, parking areas, and the relocation of about 1.75 miles of the Mount Vernon Memorial Highway. The layout of these facilities is shown in figure 1.

The investigation disclosed that the material in the runways did not consist of uniform mixtures of sand and gravel. Instead, the fill contained stratifications and pockets of sand, gravel, and cobbles, and in certain locations layers and pockets of clay and muck were encountered.

The behaviour of the existing runway material under the action of construction traffic showed a large variation in stability Some portions became well compacted while other sections remained loose and became rutted. Sponginess and rutting were observed in the mucky areas. These conditions indicated the need for stabilization in order to provide satisfactory support over the entire area to be paved.

The design called for a stabilized base 9 inches thick after compaction for the runways and taxiways located in the hydraulic fill area and a 12-inch base constructed in two 6-inch courses for the dry fill areas of the landing field as well as for the relocated Mount Vernon Memorial Highway over Four Mile Run. Access roads, service roads, parking zones, and most of the taxiways were designed to have a 5-inch compacted gravel lower course and an 8-inch stabilized gravel upper course. The stabilized base extended 3 feet beyond the edges of the asphaltic concrete surface which was 200 feet wide on the North-South and the Northwest-Southeast runways, 150 feet on the Northeast-Southwest and East-West runways, and 75 feet on the taxiways. Typical cross sections are shown in figure 2.

[1] Washington National Airport, by Lt. R. C. Tripp, Corps of Engineers, U. S. Army. The Military Engineer, September-October 1939.

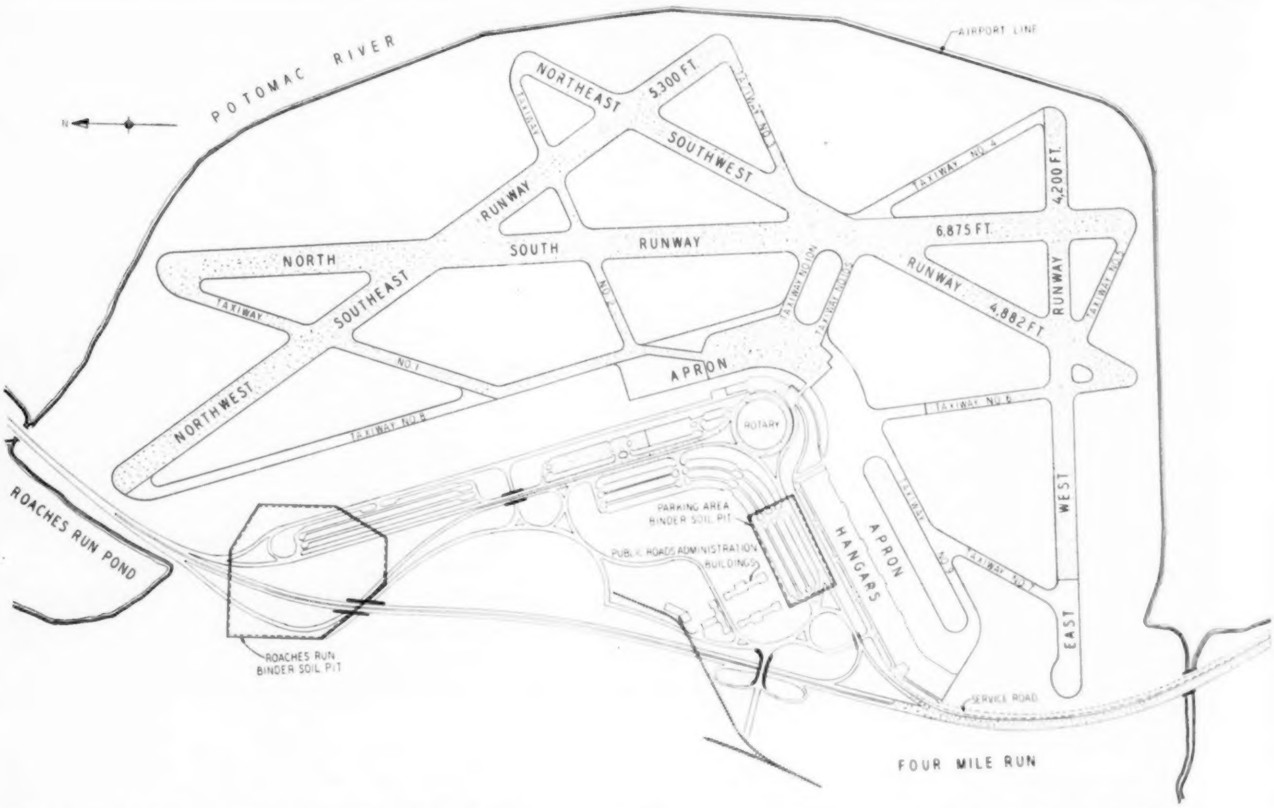


Figure 1.—Layout of Runways, Taxiways, Aprons, and Roads at the Washington National Airport. Shaded Areas Indicate Work Completed During 1940

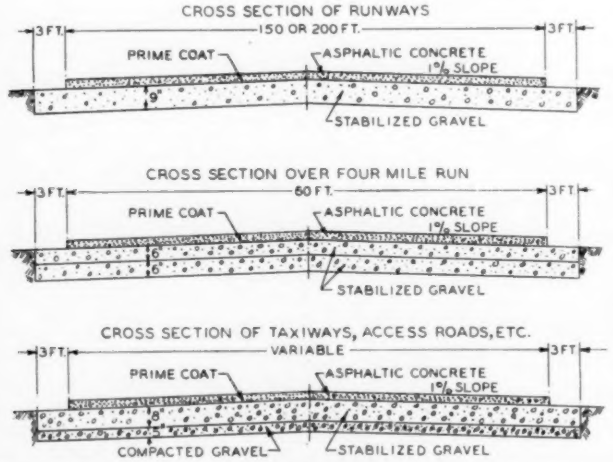


Figure 2.—Typical Paving Cross Sections, Washington National Airport.

Construction of the stabilized base was commenced on March 6, 1940, and continued until the end of the year when the stabilization operations were suspended for the winter. The work completed during this construction period, amounting to approximately 544,000 square yards of stabilized base and indicated by the shaded areas on figure 1, may be summarized as follows:

Facility:	Area completed, square yards
Runways	392,600
Taxiways	87,900
Apron	31,000
Mount Vernon Memorial Highway	21,000

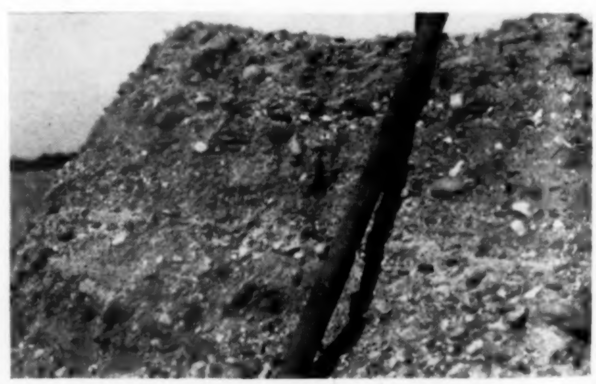


Figure 3.—Typical Formation of Gravel Deposited by Pumping Operations.

Facility—Continued.	Area completed, square yards
Access roads	7,900
Parking zones	3,600

This report, covering the participation of the Public Roads Administration in the base course stabilization, describes the character of the materials, the methods of construction and control, the sampling, testing, and proportioning of materials, and presents a summary of the results obtained.

The character of the gravel formations as deposited by the pumping operations is illustrated in figure 3. Tests performed on samples taken from the upper 12 inches of the runways (see table 1) indicated that the material, in general, was a nonplastic mixture of sand and gravel with variable amounts of large rock and

FIGURE 4.—TYPICAL EXAMPLES OF POCKETS AND LAYERS OF MUCK AND SAND. A, THIN LAYERS OF MUCK; B, POCKET OF MUCK, GRAVEL, AND ENTRAPPED WATER; C, DEEP POCKET OF SOFT MUCK; AND D, SANDY DEPOSIT WITH THIN LAYERS OF MUCK.

cobbles. The percentage of large rock varied considerably from place to place. After removing this material, however, the remaining sand and gravel was fairly well graded but was lacking in material passing the No. 200 sieve. As a result, it was decided to stabilize the gravel by the addition of a binder soil from the adjacent upland area.

In addition to variations in the amount of large rock in the gravel fill, layers and pockets of muck and fine sand were encountered in many locations. These conditions are illustrated in figure 4. Mechanical analyses and physical properties typical of these materials are given in table 2.

TABLE 1.—*Results of tests performed on samples typical of gravel pumped into runways of Washington National Airport*

SIEVE ANALYSIS

	Sample No.—							
	1	2	5	7	9	12	13	16
Percentage passing:								
2-inch sieve	86	100	100	92	96	63	75	100
1½-inch sieve	86	95	96	89	93	58	70	98
1-inch sieve	85	85	95	81	89	53	62	93
¾-inch sieve	80	71	92	71	82	46	56	86
⅜-inch sieve	65	53	79	51	62	36	45	71
No. 4 sieve	53	40	66	37	44	29	36	58
No. 10 sieve	42	34	55	25	32	24	29	48
No. 40 sieve	25	27	36	14	13	11	18	34
No. 200 sieve	3	2	5	7	2	2	5	5

PHYSICAL CONSTANTS OF MATERIAL PASSING NO. 40 SIEVE

	1	2	5	7	9	12	13	16
Liquid limit	(1)	(1)	(1)	[2] 30	(1)	(1)	(1)	(1)
Plasticity index				9				

[1] Nonplastic.
[2] Sample No. 7 was taken in an area containing a thin layer of muck.

TABLE 2.—*Typical analyses of muck and sandy material*

	Sand	Muck
Mechanical analysis:		
Coarse sand (2.0 to 0.25 mm.) ... percent	16	4
Fine sand (0.25 to 0.05 mm.) ... do	61	5
Silt (0.05 to 0.005 mm.) ... do	16	24
Clay (smaller than 0.005 mm.) ... do	7	57
Physical properties:		
Liquid limit	19	71
Plasticity index	(1)	27
Shrinkage limit		31
Shrinkage ratio		1.4
Centrifuge moisture equivalent	7	51
Field moisture equivalent	31	53

[1] Nonplastic.

The formations consisting largely of fine sand were quite spongy when associated with a high water table resulting from blocked drainage. These areas were drained but the material itself was too fine to produce a stabilized base by means of an admixture of binder soil. It was necessary to add both gravel and binder soil.

The muck had physical characteristics typical of the group A-8 subgrades. It was extremely unstable and had to be removed and replaced with gravel during the construction of the stabilized base.

FOUR DIFFERENT GRADINGS PERMITTED IN STABILIZED MIXTURES

Two portions of the upland area, one at Roaches Run and the other at the proposed parking zone south of the Public Roads Administration laboratories (fig. 1), were designated as the locations most convenient for obtaining binder soil without interfering with the grading operations. Accordingly, a soil survey of these areas was made to determine the character and quantities of soils available for use as binder material for stabilization.

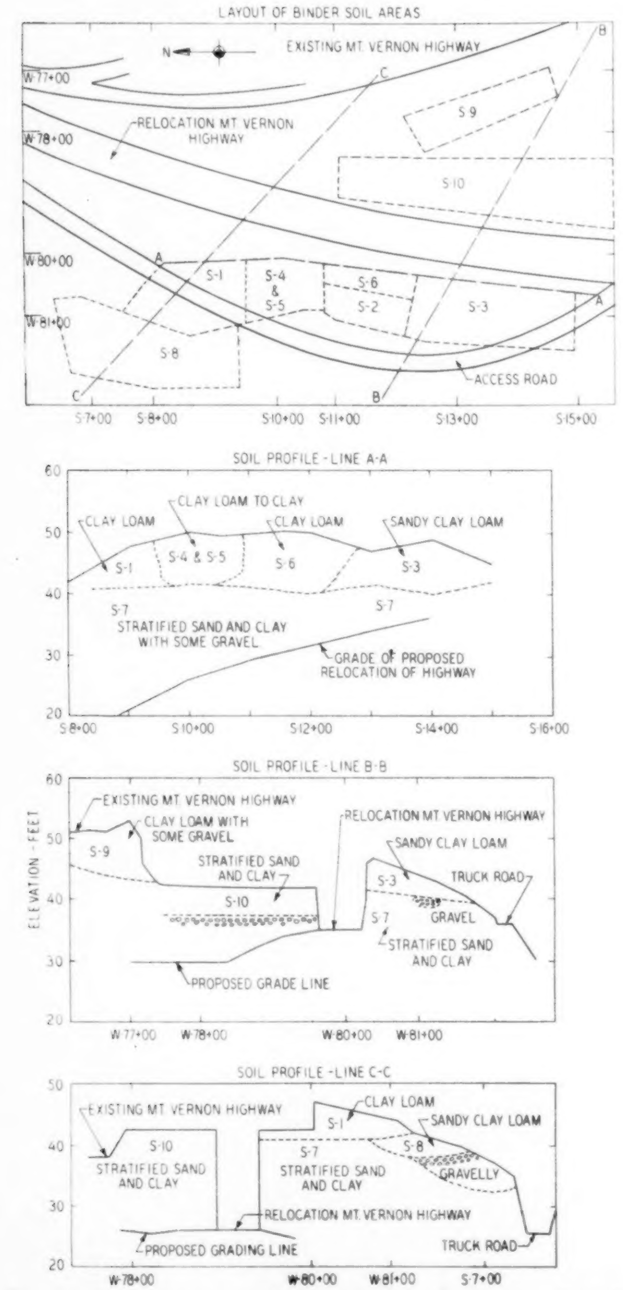


FIGURE 5.—LAYOUT AND SOIL PROFILES OF BINDER SOIL PIT AT ROACHES RUN.

Borings were made to determine the soil profiles and samples representative of the different layers of the profile were taken and tested in the Public Roads Administration soils laboratory. The soil profiles for the Roaches Run pit are shown on figure 5 and the results of tests performed on the samples of soil are given in table 3. The soil profiles and test results for the parking area pit are presented in figure 6 and table 4.

With the exception of the material designated S–7, all of the soils encountered in the two pits were found to be satisfactory for use as binder soil. The S–7 material was too sandy for this purpose. Approximately 24,000 cubic yards of binder soil of acceptable quality was available in the Roaches Run pit and about 27,000 cubic yards in the parking area pit, making a total of

TABLE 3.—*Results of tests performed on samples from Roaches Run binder soil pit, Washington National Airport*

SIEVE ANALYSIS

	Sample No.—									
	S–1	S–2	S–3	S–4	S–5	S–6	S–7	S–8	S–9	S–10
Percentage passing:										
No. 10 sieve	100	100	100	100	100	100	100	100	100	100
No. 40 sieve	98	96	98	99	99	99	95	96	99	97
No. 60 sieve	94	74	89	97	95	95	75	85	95	83
No. 200 sieve	66	32	48	82	70	65	25	49	66	40
HYDROMETER ANALYSIS OF MATERIAL PASSING NO. 10 SIEVE										
Sand, percent	41	72	57	24	37	42	79	57	43	65
Silt, percent	31	10	20	42	30	31	10	20	36	20
Clay, percent	28	18	23	34	33	27	11	23	21	15
PHYSICAL CONSTANTS OF MATERIAL PASSING NO. 40 SIEVE										
Liquid limit	26	23	27	33	31	29	19	23	25	19
Plasticity index	9	4	9	11	12	9	0	6	7	2

TABLE 4.—*Results of tests performed on samples from parking area binder soil pit, Washington National Airport*

SIEVE ANALYSIS

	Sample No.—					
	P–1	P–2	P–3	P–4	P–5	P–6
Percentage passing:						
No. 10 sieve	100	100	100	100	100	100
No. 40 sieve	99	99	99	99	99	99
No. 60 sieve	97	87	97	94	98	90
No. 200 sieve	76	40	78	63	83	57
HYDROMETER ANALYSIS OF MATERIAL PASSING NO. 10 SIEVE						
Sand, percent	31	65	28	43	22	48
Silt, percent	37	17	38	30	36	28
Clay, percent	32	18	34	27	42	24
PHYSICAL CONSTANTS OF MATERIAL PASSING NO. 40 SIEVE						
Liquid limit	30	22	31	28	38	25
Plasticity index	10	4	10	10	17	8

51,000 cubic yards which was more than sufficient for the proposed stabilization.

The acceptable soil materials in general were yellowish and yellowish-red sandy loams and clay loams. They were friable in consistency and could be readily pulverized. With respect to the gradations of the samples, the fraction passing the No. 200 sieve ranged from 32 to 83 percent. The liquid limits varied from 19 to 38 and the plasticity indexes from 2 to 17.

In order to provide for variations in the materials encountered in the runways, four different gradings were permitted in the stabilized mixtures. They were based on the maximum size of the gravel in the mixture after the large rock and cobbles had been removed. The permissible gradings limits are given in table 5.

It was required that the gravel be combined with binder soil in such proportions that the resulting mixture would fall within the limits of grading B, C, D, or E, whichever best fitted the material available. However, since it was desired to use any suitable material existing in the runways that would be satisfactorily stabilized, some tolerance from the limits given in table 5 was allowed at the discretion of the engineer.

In addition to the grading requirements, it was required that the fraction passing the No. 200 sieve

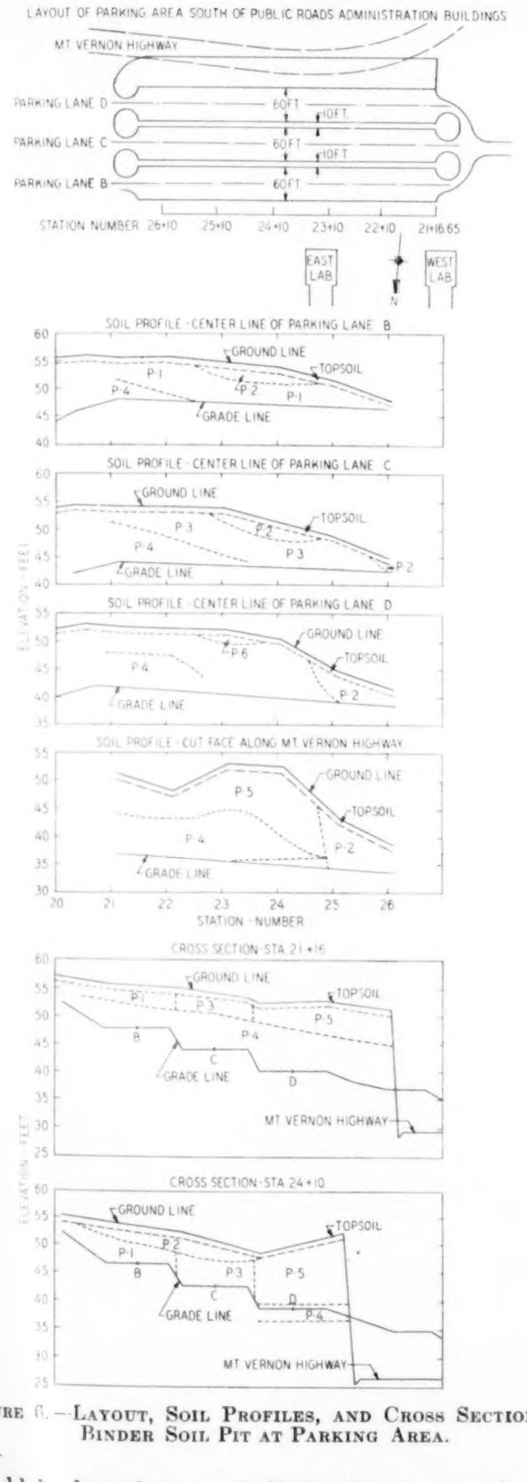


FIGURE 6.—LAYOUT, SOIL PROFILES, AND CROSS SECTIONS OF BINDER SOIL PIT AT PARKING AREA.

should be less than one-half the fraction passing the No. 40 sieve, and also that the fraction passing the No. 40 sieve should have a liquid limit not greater than 25 and a plasticity index not greater than 6.

Control over the base stabilization in accordance with these requirements was accomplished by coordinating the construction operations with the tests performed on the raw materials and the mixtures. This work was directed from a portable field laboratory (fig. 7) located on the runways.

FIGURE 7.—PORTABLE LABORATORY (CENTER) AND OFFICES ON RUNWAYS.

TABLE 5.—*Gradation requirements for stabilized mixtures*

Sieve designation	Percentage by weight passing square mesh sieves			
	Grading B	Grading C	Grading D	Grading E
3-inch	100			
2-inch	65–100	100		
1½-inch		70–100		
1-inch	45–75	55–85	100	
¾-inch		50–80	70–100	90–100
⅜-inch	30–60	40–70	50–80	70–100
No. 4	25–50	30–60	35–65	50–90
No. 10	20–40	20–50	25–50	35–80
No. 40	10–25	10–30	15–30	20–50
No. 200	3–10	5–15	5–15	8–25

The rough grading was generally performed by bulldozers which pushed the surcharged fill materiall off to the sides of the area to be stabilized. When gravel was needed in other locations, it was pushed into large piles by the bulldozers and loaded into trucks by means of a dragline (fig. 8–A). Motor patrol graders were used to bring the runway to approximate grade and cross section.

Many areas containing unstable mucky materials were encountered during the grading operations. When the muck was in the form of seams or thin layers, it was excavated by means of large tractor-drawn scrapers (fig. 8–B). Deep pockets were removed with draglines (fig. 8–C). All muck deposits were removed to a minimum depth of 3 feet below subgrade elevation and replaced with gravel.

After the grading was completed, the runway material was scarified with a heavy-duty rooter (fig. 8–D) to an approximate depth of 12 inches. The scarified gravel was then further loosened with a field cultivator and all oversized stone brought to the surface (figs. 8–E and 8–F) were removed by hand. These operations were continued until the depth to be stabilized was, for all practical purposes, free of all stones larger than about 3 inches and other objectionable material such as clay balls.

When sections of the runway had been satisfactorily cleared of oversize stone and other undesirable material, samples were taken from the 12 inches of loosened material and their gradations were determined in the laboratory. At the same time, samples of binder soil were obtained from the pit and analyzed. The percentage of binder soil to be added to the gravel and the area to be covered by each load of binder soil was calculated from the results of these tests.

MATERIALS THOROUGHLY MIXED AND COMPACTED

As the removal of the stone from a section sufficiently large to permit satisfactory operation of the mixing equipment was nearing completion, a crew of

FIGURE 8.—CONSTRUCTION OF RUNWAYS: A, GRADING OPERATIONS; B, THIN LAYERS OF MUCK BEING EXCAVATED BY SCRAPER; C, DEEP MUCK BED BEING EXCAVATED BY DRAGLINE; D, SCARIFYING MATERIAL WITH HEAVY-DUTY ROOTER; E. OVERSIZE STONE BROUGHT TO SURFACE BY SCARIFYING; AND F, OVERSIZE STONE IN EXCESSIVE AMOUNTS GENERALLY ENCOUNTERED AT RUNWAY INTERSECTIONS.

laborers was sent to the binder soil pit where a bulldozer had stripped off the topsoil containing vegetable matter and had pushed up a large pile of approved binder soil. The binder soil was loaded by hand into transportable, bottom dump, 2-cubic yard boxes (fig. 9–A), hauled to the runways, dumped (fig. 9–B), and spread by hand over an area previously staked out in accordance with instructions issued by the testing laboratory.

The first step in the mixing was to cut in the binder soil by means of the field cultivator (fig. 9–C). This was followed by one trip with a two-way tandem disk harrow (fig. 9–D) equipped with disks 28 inches in diameter. In order to facilitate the distribution of the binder soil through the full depth to be stabilized, the disked material was turned with a four-bottom gang plow (fig. 9–E). Mixing with the disk harrow and cultivator was then continued until the binder soil and gravel were thoroughly and uniformly mixed to the specified depth.

Water was applied (fig. 9–F) whenever necessary during the mixing operations. The need for water was determined by the requirements for compaction. Tests made on the base course material in locations where satisfactory compaction was obtained showed that 5 to 7 percent of moisture was required to give the desired results. This checked very closely with the optimum moisture content of 10 percent (American

Figure 9.—Stabilization of Runways: A, Loading Binder Soil in 2-Cubic Yard Boxes; B, Depositing and Spreading Binder Soil; C, Cutting in Binder Soil with Field Cultivator; D, Mixing with Two-way Tandem Disk Harrow; E, Turning Disked Material with Four-bottom Gang Plow; and F, Sprinkling During Mixing Operations.

Association of State Highway Officials' Method T 99–38) on the material passing the No. 4 sieve, which averaged about 60 percent of the total mixture.

While the mixing was in progress, frequent checks were made on the moisture content, the uniformity of the mixture, and the depth of the mixed material.

The loose mixture of gravel and soil was bladed to approximate cross section with a motor patrol and then compacted with multi-wheel, pneumatic-tired rollers (fig. 10–A) weighing about 6 tons. This rolling was continued until an unyielding surface was produced under the weight of these rollers. At least two trips were required to obtain this condition. The appearance of the compacted mixture is illustrated in figure 10–B. Final compaction was obtained by means of a three-wheel, 10-ton roller (fig. 11–A). The motor patrol (fig. 11–B) and a multiple-blade drag (fig. 11–C) were used to keep the surface properly shaped during rolling.

The surface was maintained in a moist condition by sprinkling while these operations were in progress.

Weak spots which developed in the base or subgrade during the rolling were examined by means of test pits and corrected according to the needs of the particular case. A further check on the subgrade stability was obtained by operating a 12-ton, solid-tired truck (fig. 12–A) over the compacted surface. A failure due to weak subgrade is shown in figure 12–B.

After the base had been compacted to a minimum dry density of 130 pounds per cubic foot, the elevation and cross section was checked by an engineering party. Final shaping consisted of cutting the high spots and filling in low areas in accordance with stakes driven to

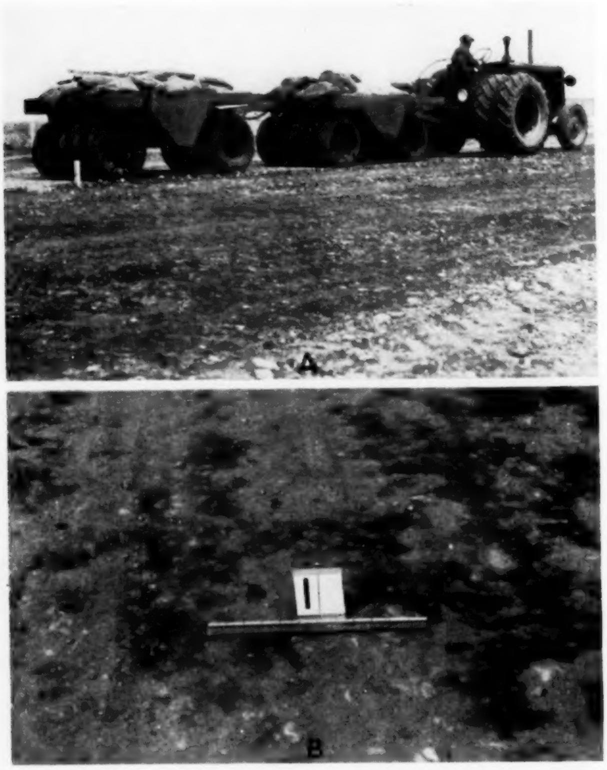


FIGURE 10.—A, COMPACTING STABILIZED BASE WITH PNEUMATIC-TIRED ROLLERS; AND B, APPEARANCE OF BASE AFTER COMPACTING WITH PNEUMATIC-TIRED ROLLERS.

FIGURE 11.—A, COMPACTION WITH 3-WHEEL, 10-TON ROLLER; SHAPING, DURING ROLLING, WITH MOTOR PATROL (B), AND WITH MULTIPLE BLADE DRAG (C).

grade elevation at 25-foot intervals. This work was performed by hand or by motor patrol depending on the size of the area to be corrected. The surface was then finished by rolling with an 8-ton tandem roller (fig. 12–C). The appearance of the completed base course is shown in figure 12–D.

The quality of the stabilized mixture was checked by tests performed on samples taken at regular intervals after the mixing was completed. When the results of tests indicated an unsatisfactory mixture at a certain location, additional samples were obtained in sufficient number to determine the limits of the area in this condition. All such areas were reconstructed.

The final step in the stabilization procedure was an application of tar prime at a rate of about 0.25 gallon per square yard. Application of the tar was not permitted until the base course conformed with all the requirements relating to quality of mixture, density, and stability.

The same procedure was followed for each layer of the two-course construction on the Four Mile Run fill and for the upper 8 inches on the taxiways, access roads, etc. (see fig. 2).

STABILIZED MIXTURES TESTED TO DETERMINE CONFORMITY WITH REQUIREMENTS

The results of the sieve analyses performed on the samples of stabilized mixtures from the runways are summarized in table 6. These results are shown graphically in figure 13. The samples were grouped into gradation ranges corresponding as closely as possible to the grading requirements given in table 5.

None of the samples had a gradation typical of the B grading. This grading was included in the requirements on the basis of materials represented by samples 12 and 13 in table 1. However, practically all of the material remaining after removal of the oversize stone during the construction operations was smaller than 2 inches. Only one sample had more than 10 percent retained on the 2-inch sieve and was included with the samples in grading C.

The range in gradations designated D–E was made necessary by the fact that almost all the gravel samples had some material retained on the 1-inch sieve but many of these could not be placed in the C or D grading because of the high percentages passing the smaller-sized sieves. Many of the samples with material coarser than 1 inch had more than 80 percent smaller than the $\frac{3}{4}$-inch sieve. These samples generally had more material passing the No. 10 and No. 40 sieves, even before the addition of binder soil, than was permitted in the specifications for the C and D gradings. Since binder soil was required in practically all instances,

TABLE 6.—*Summary of results of sieve analyses performed on stabilized mixtures from runways on Washington National Airport*

RANGE IN GRADATION [1]

Sieve designation	Percentage by weight passing square mesh sieves			
	Grading C	Grading D	Grading D-E	Grading E
2-inch	89-100	93-100	100	------
1½-inch	80-100	86-100	91-100	100
1-inch	72-85	86-92	86-100	95-100
¾-inch	63-80	75-80	81-90	91-100
⅜-inch	49-65	51-70	63-79	78-91
No. 4	40-56	38-60	47-70	65-83
No. 10	34-47	29-53	37-64	54-76
No. 40	22-35	16-36	19-45	25-57
No. 200	4-13	3-13	4-14	3-19
AVERAGE GRADATION				
2-inch	99	100	100	------
1½-inch	89	96	98	100
1-inch	81	88	92	98
¾-inch	75	78	86	95
⅜-inch	61	62	71	85
No. 4	51	51	60	74
No. 10	43	42	50	63
No. 40	27	26	30	41
No. 200	8	8	8	11

[1] Range in gradation shows the maximum and minimum percentages passing each sieve for the particular group of samples falling within the grading band indicated.

the gradations of the resulting mixtures could not possibly fall within the limits specified. For this reason, all samples having between 80 and 90 percent passing the ¾-inch sieve were included in the D-E grading while those having more than 90 percent finer than the ¾-inch sieve were placed in the E grading.

The samples having 80 percent or less passing the ¾-inch sieve were placed in the C grading if the amount smaller than the 1-inch sieve did not exceed 85 percent and in the D grading when the percentage finer than the 1-inch sieve was greater than 85 percent.

The ratios of the fractions passing the No. 200 sieve to the fractions passing the No. 40 sieve ranged from 0.14 to 0.50 with an average of 0.27 for all the samples from the runways.

With respect to the physical properties of the fractions passing the No. 40 sieve, the results of tests may be summarized as follows:

Maximum liquid limit	23
Average liquid limit	18
Maximum plasticity index	6
Average plasticity index	1

A liquid limit of 25 and a plasticity index of 6 were the maximum permitted. In the design of the mixture an attempt was made to hold the plasticity index to 3 or less in order to insure a stable base course under adverse moisture conditions. Only 4 percent of the samples tested had plasticity indexes higher than 3 while 36 percent had plasticity indexes of zero. Another 36 percent were so granular that the plasticity index could not be determined. Of interest in this connection is the fact that the nonplastic mixtures were compacted just as readily as those having a measurable plasticity index.

The base course densities obtained on the runways ranged from 126 to 143 pounds per cubic foot with an average dry density of 134 pounds per cubic foot as compared with the density of 135 pounds per cubic foot used in designing the mixture. The low density of 126 pounds per cubic foot was obtained on the northwest end of the Northwest-Southeast runway. This portion of the runway was constructed before arrangements had been made to control the density or to check the stability of the subgrade.

FIGURE 12.—A, CHECKING BASE STABILITY WITH A 12-TON, SOLID-TIRED TRUCK; B, FAILURE DUE TO WEAK SUBGRADE; C, FINAL ROLLING WITH AN 8-TON TANDEM ROLLER, AND D, APPEARANCE OF COMPLETED BASE COURSE.

After the minimum density requirement of 130 pounds per cubic foot was established, lower densities were permitted only when the amount of rolling indicated that no increase in density could be obtained. Such conditions were encountered in a few isolated cases where the mixtures were sandy rather than gravelly in character. These mixtures had densities ranging from 128 to 130 pounds per cubic foot.

In addition to the determination of the density of the 9-inch compacted base course, tests were made at three

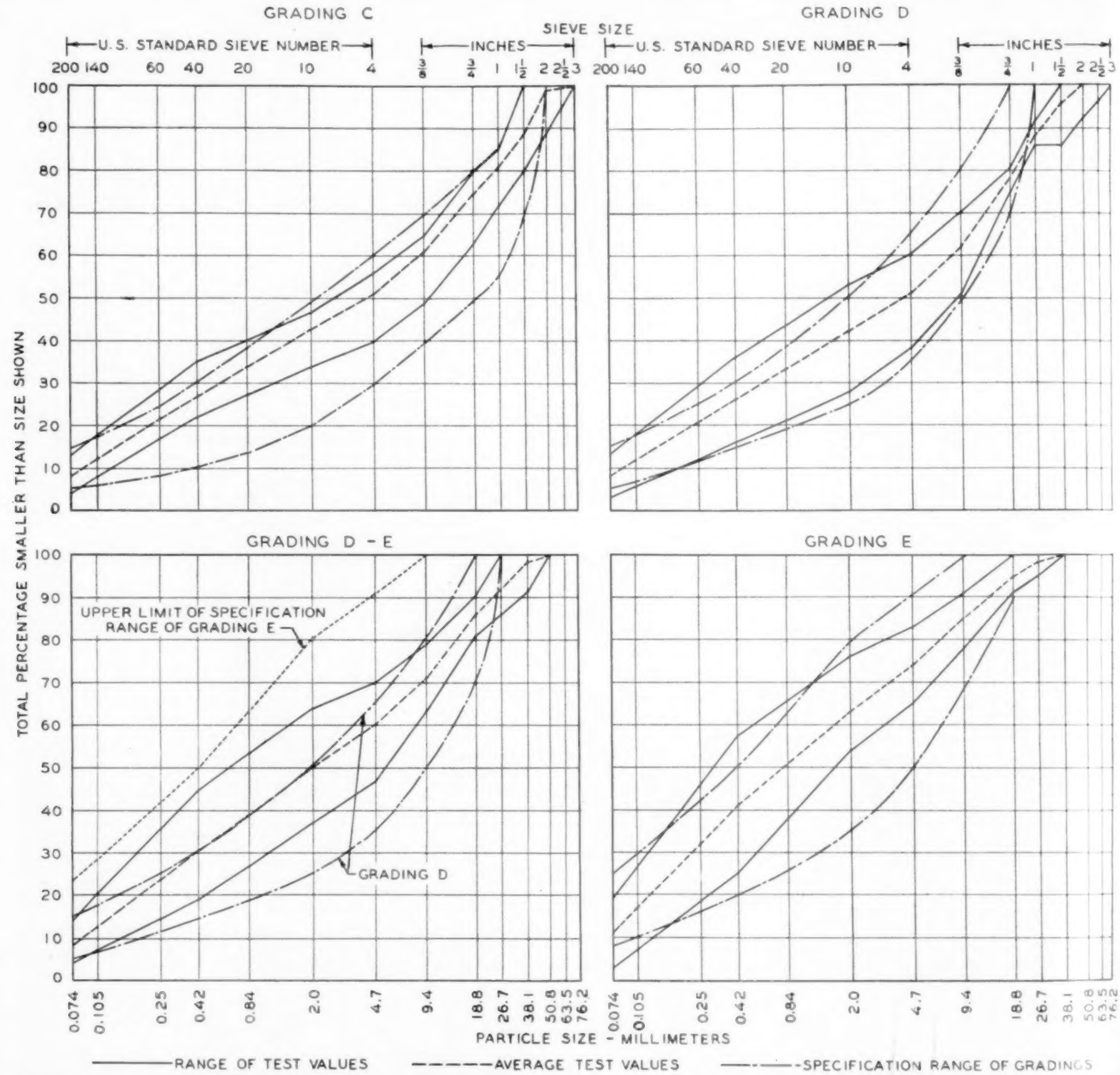


FIGURE 13.—RESULTS OF SIEVE ANALYSES OF STABILIZED BASE COURSE MIXTURES COMPARED WITH SPECIFICATION REQUIREMENTS.

locations on the Northwest-Southeast runway to determine the density of the upper 4½ inches. The two tests at each location were at places not more than 12 inches apart. The results are given in table 7.

TABLE 7.—*Densities of samples from Northwest-Southeast runway*

Station	Thickness tested	Dry density
	Inches	*Pounds per cubic foot*
36+50	4½	134.1
	9	129.4
40+50	4½	138.5
	9	134.2
44+50	4½	133.7
	9	130.6

These results show that the density of the upper half of the compacted stabilized base was about 103 percent of the density of the full 9 inches. On this basis the average density of 134 pounds per cubic foot for the 9-inch thickness indicates a density of 138 pounds per cubic foot in the upper 4½ inches. Assuming that the density for the 9-inch thickness is equal to the average of the densities of the upper and lower 4½ inches, the density of the lower 4½ inches may be calculated by multiplying the density of the 9-inch thickness by 2 and subtracting the density of the upper 4½ inches. The values obtained in this manner for stations 36+50, 40+50 and 44+50 are respectively 124.7, 129.9 and 127.5 pounds per cubic foot which correspond to densities averaging 94 percent of the densities of the upper 4½ inches and 97 percent of the densities of the full 9 inches.

The moisture contents of the base course, determined as a part of the density test, varied from 2.3 to 7.2 percent with an average of 4.4 percent.

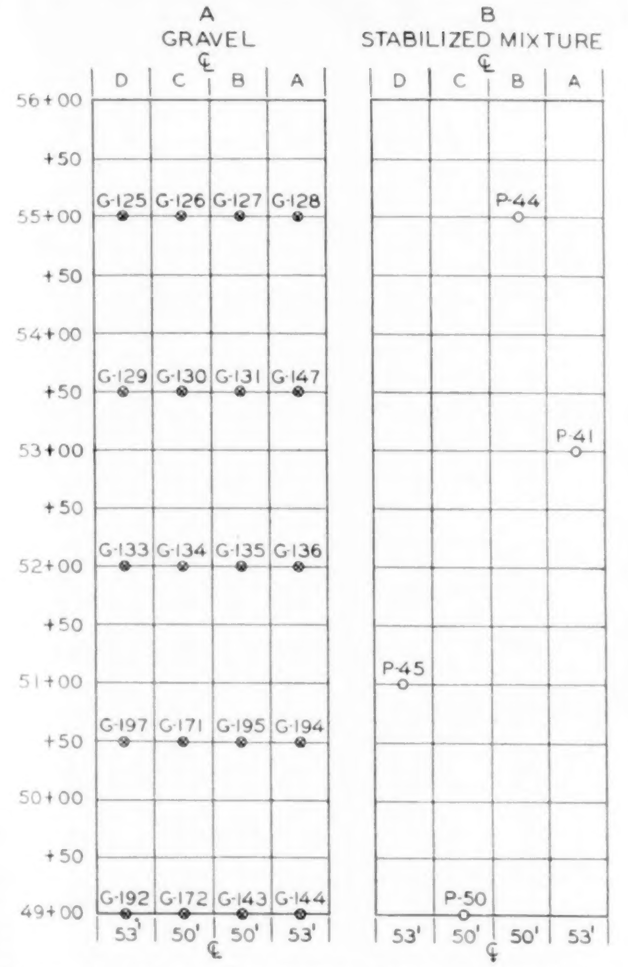


FIGURE 14.—PLAN OF LOCATIONS AT WHICH VARIOUS SAMPLES WERE TAKEN.

Tests made at three different locations on the North-South runway disclosed an average density of 125 pounds per cubic foot after four trips with the pneumatic-tired roller. After two trips with the three-wheel roller, the average density was increased to 128.7 pounds per cubic foot, and two additional trips increased it to 133.3 pounds per cubic foot.

SAMPLING AND TESTING PROCEDURES DESCRIBED

Sampling of the gravel consisted of digging a hole 12 inches deep in the graded runway after the oversize stone had been removed and collecting approximately 15 pounds of material from the sides of the hole. The runways were divided into strips 50 or 53 feet wide and samples were taken from each strip at intervals of 150 feet as illustrated in figure 14. The samples were placed in dust-tight canvas bags and delivered to the portable field laboratory which was located as close as possible to the section of the runway under construction.

The sample was first dried in shallow pans over a gasoline camp stove (fig. 15–A); it was stirred continuously to prevent burning. After the dried sample had cooled off, it was quartered down to about 4 pounds, placed in a pan, and ground with a rubber-covered pestle to break up the aggregation of particles. Any fine material having a tendency to adhere to the coarse gravel was removed with a wire brush. All of the

FIGURE 15.—LABORATORY TESTS ON SAMPLES. A, DRYING GRAVEL SAMPLES ON DOUBLE-BURNER GASOLINE CAMP STOVES; AND B, DETERMINING WEIGHTS OF MATERIAL RETAINED ON VARIOUS SIEVES.

material was then shaken through a nest of sieves ranging in size from the maximum to the minimum called for in the gradation requirements for the stabilized mixtures. The fraction retained on each sieve added to that retained on the sieves with larger openings was weighed (fig. 15–B) and the percentage of the total sample retained on each sieve was calculated. The form used for recording the data is shown in figure 16.

At the start of the work, samples of binder soil were obtained from the pit. After the hauling was commenced, samples were taken from the soil deposited on the runways. These samples were tested for moisture content as well as gradation, which was determined in the same manner as for the gravel.

One sample of the stabilized mixture was taken for each 200 lineal feet of runway as shown in figure 14–B. Some of these samples were tested in the portable field laboratory. The majority, however, were sent to the Public Roads Administration laboratory where their gradations, liquid limits, and plasticity indexes were determined in accordance with the standard methods of the American Association of State Highway Officials.

In practically all cases, the gravel required the addition of binder soil in order to provide a stable mixture. It was found that with the materials available best results were obtained with a mixture having approximately 7 or 8 percent passing the No. 200 sieve for the B, C, and D gradings and about 10 or 11 percent for the E grading. Tests performed on the mixtures showed that the liquid limit and plasticity index requirements could be satisfied with any acceptable gradation resulting from the combination of the existing gravel with the binder soils used on this project.

This simplified the proportioning to the considera-

FEDERAL WORKS AGENCY
PUBLIC ROADS ADMINISTRATION
Washington, D. C.

Sieve Analyses Record - Washington National Airport

Sample No. G-127 Date 5-9-40
Station 55+00
Location B Lane
North - South Runway

Sieve	Retained: Weight grams	Retained: Percent	Passing Percent	Variation from grading limits Type......
3 in.				
2 in.			100	
1 in.	142	11	89	
3/4 in.	263	20	80	
3/8 in.	528	39	61	
No. 4	757	56	44	
No. 10	885	66	34	
No. 40	1097	82	18	
No. 200	1318	98	2	

Passing No. 200 sieve .....27...... grams
Wt. of total sample .....1345...... grams
Tested by....K.... Checked by....T.......

Sample No. ________ Date ________
Station ________
Location ________

Sieve	Retained: Weight grams	Retained: Percent	Passing Percent	Variation from grading limits Type......
3 in.				
2 in.				
1 in.				
3/4 in.				
3/8 in.				
No. 4				
No. 10				
No. 40				
No. 200				

Passing No. 200 sieve .... grams
Wt. of total sample .... grams
Tested by .... Checked by...........

Sample No. ________ Date ________
Station ________
Location ________

Sieve	Retained: Weight grams	Retained: Percent	Passing Percent	Variation from grading limits Type......
3 in.				
2 in.				
1 in.				
3/4 in.				
3/8 in.				
No. 4				
No. 10				
No. 40				
No. 200				

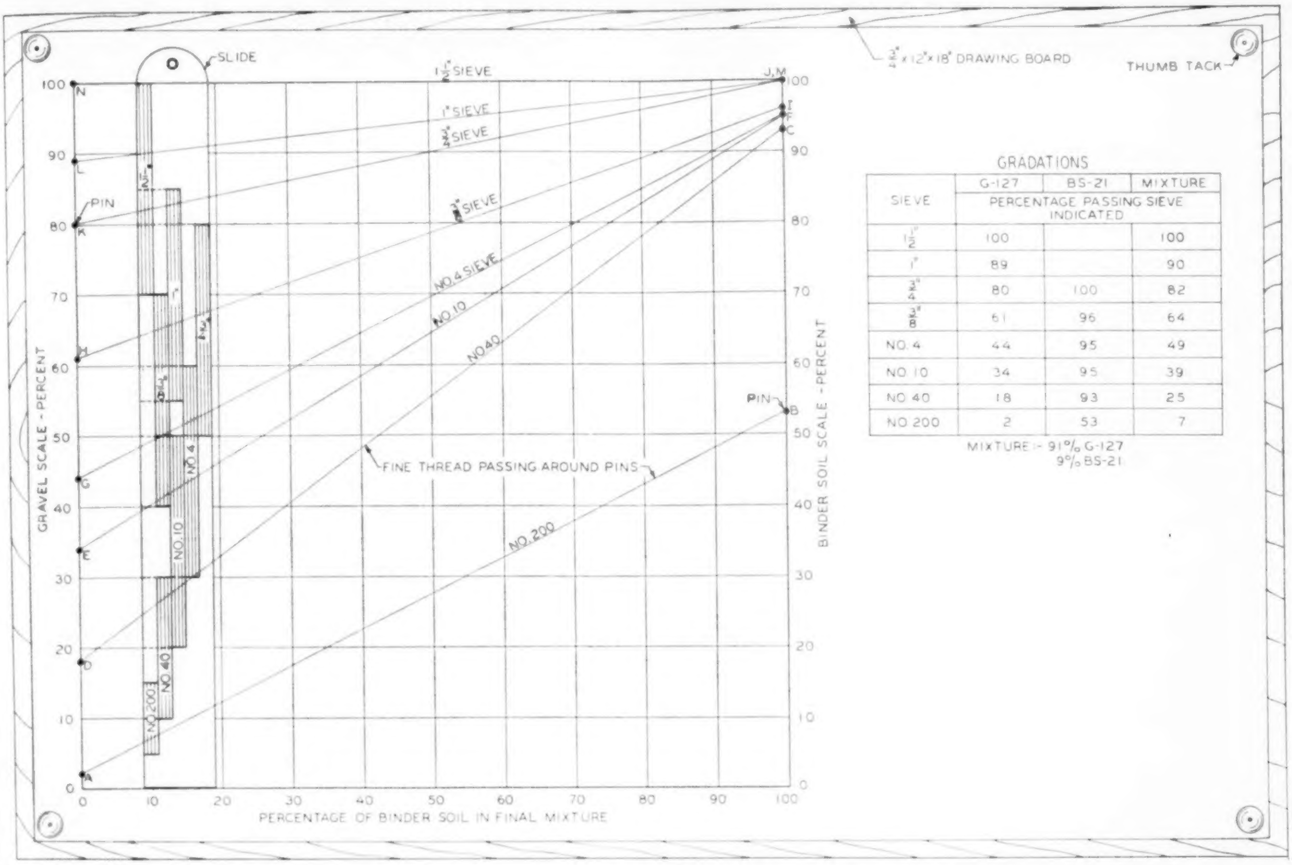
Passing No. 200 sieve ....grams
Wt. of total sample .... grams
Tested by......... Checked by ....

Sample No. ________ Date ________
Station ________
Location ________

Sieve	Retained: Weight grams	Retained: Percent	Passing Percent	Variation from grading limits Type......
3 in.				
2 in.				
1 in.				
3/4 in.				
3/8 in.				
No. 4				
No. 10				
No. 40				
No. 200				

Passing No. 200 sieve .... grams
Wt. of total sample .... grams
Tested by .... Checked by...........

FIGURE 16.—FORM USED FOR RECORDING SIEVE ANALYSES.



SIEVE	G-127	BS-21	MIXTURE
	PERCENTAGE PASSING SIEVE INDICATED		
1½"	100		100
1"	89		90
¾"	80	100	82
⅜"	61	96	64
NO. 4	44	95	49
NO. 10	34	95	39
NO. 40	18	93	25
NO. 200	2	53	7

FIGURE 17.—GRAPHICAL METHOD FOR PROPORTIONING TWO SOIL MATERIALS TO PRODUCE SPECIFIED GRADING OF STABILIZED MIXTURE.

tion of grading alone. On the basis of their gradations, the proper proportions of the two materials, gravel and binder soil, were determined by either the trial-and-error method or the graphical method. The trial-and-error method consisted of assuming a certain percentage of binder soil to add to the gravel and calculating what the resulting mixture would be. If this assumed percentage did not prove satisfactory other percentages were tried until the calculations indicated a suitable mixture. After a little experience with the available materials, the desired combination could be obtained on the first trial.

The proportioning of the materials by the graphical method was performed using the mechanical device illustrated in figure 17. This consisted of a 12- by 18-inch drawing board on which was mounted a piece of cross section paper at least 10 inches long by 10 inches wide and having 10 divisions to the inch in each direction, a movable paper scale, several pins (represented by the small circles on the figure), and a fine thread looped around the pins. The fine thread is represented in figure 17 by the lines connecting the pins and having sieve designations.

GRAPHICAL METHOD USED IN PROPORTIONING MIXTURE

The movable scale is a strip of cross section paper having the same vertical scale as the fixed sheet. The limits of the specified grading are blocked off on this scale. A different movable scale had to be made for each grading band.

The operation of this device may best be illustrated by an example. For convenience in following the procedure, the sieve analyses of gravel sample 127 (G–127) and binder soil sample 21 (BS–21) which are to be combined are shown on figure 17. The first step is to place pins along the vertical scales of the fixed sheet at points corresponding to the percentages passing the various sieves, on the left for the gravel and on the right for the binder soil. Next, the end of the fine thread is tied to pin A marking the percentage of gravel passing the No. 200 sieve (2 percent) and stretched across to pin B designating the percentage of binder soil passing the same sieve (53 percent). The thread is then extended straight up along the binder soil scale to pin C, across to pin D, up along the gravel scale to pin E, across to pin F, and so on to pins G, H, I, J, K, L, M, and ending at pin N.

The movable scale is placed under the threads along the pins on the left side and then moved to the right until the line (indicated by the left edge of movable scale) is reached where the greatest number of threads are crossing within the limits specified for the corresponding sieve sizes marked on the scale. The intersection of this line with the horizontal scale at the bottom of the sheet indicates the percentage of binder soil to be added to the particular sample of gravel, while the gradation of the mixture produced by this combination is read on the vertical scale at the points where this line intersects the lines formed by the different segments of the thread running across the sheet between the pins.

The calculation of the binder soil distribution was based on (1) the compacted dry density of the stabilized base assumed for design purposes as 135 pounds per

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PUBLIC ROADS ADMINISTRATION
Washington, D.C.

Binder Soil Distribution Calculation - Washington National Airport

Design data:

Compacted weight of stabilized mixture (lbs. per cu. ft.)....135..... Computed by....K.............
Thickness stabilized (inches) ....9.....
Compacted weight of stabilized mixture (lbs. per sq. yd.)...911..... Checked by ....T.............
Date ..5-9-40...............

Binder soil pit	R.R.	R.R.	R.R.	R.R.			
Binder soil type	BS-21	BS-21	BS-21	BS-21			
Moisture content (percent)	8	12	8	8			
Binder soil required (percent)	4	6	9	9			
Binder soil per load (lbs.)	4870	4870	4870	4870			
Dry binder soil required (lbs. per sq. yd.)	36	55	82	82			
Moist binder soil required (lbs. per sq. yd.)	39	59	89	89			
Distribution (sq. yds. per load)	125	83	55	55			
Width of spread (ft.)	26½	25	25	25			
Lineal distance per load (ft.)	42	29	20	20			
Gravel samples represented	125	126	127	131			

R.R. denotes Roaches Run

FIGURE 18.—FORM USED FOR CALCULATION OF BINDER SOIL DISTRIBUTION.

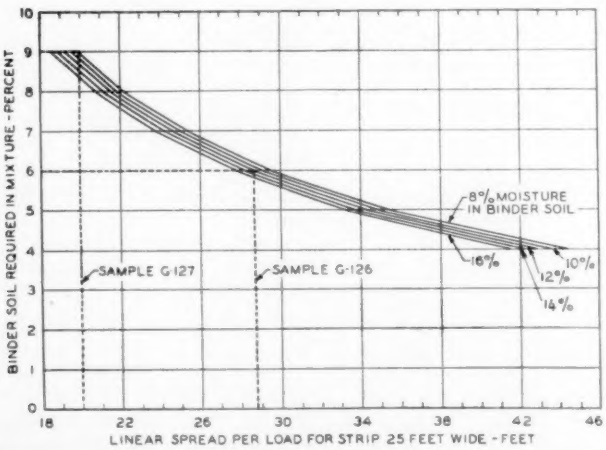


FIGURE 19.—GRAPHICAL DETERMINATION OF BINDER SOIL DISTRIBUTION

cubic foot, (2) the moisture content of the soil as determined in the laboratory, (3) the percentage of binder soil in the mixture determined as described above, and (4) the weight of soil contained in the 2-cubic yard transportable box which was found to average 4,870 pounds. The variation in weight of any individual load from the average was negligible in amount.

The form used for the calculation is illustrated in figure 18. On the basis of a dry density of 135 pounds per cubic foot, the weight of dry materials in 1 square yard of compacted stabilized base, 9 inches thick, equals 911 pounds. The amount of dry binder soil in pounds per square yard to be spread on the runway is equal to 911 multiplied by the percentage of binder soil in the mixture divided by 100. In the case of gravel sample 127 and binder soil sample 21, for example, this amounts to $\frac{911 \times 9}{100}$ or 82 pounds. Correcting for a moisture content of 8 percent, this value becomes 82×1.08 or 89 pounds of moist binder soil per square yard. Dividing the weight of a load of binder soil (4,870 pounds) by 89 gives 55 square yards as the area covered by one load of binder soil.

For convenience in spreading by hand, the width of spread for each load was fixed at a maximum of 25 feet for the inside 50-foot strips of the runways and 26½ feet for the outside strips 53 feet wide. The linear distance in feet per load was computed for the corresponding width.

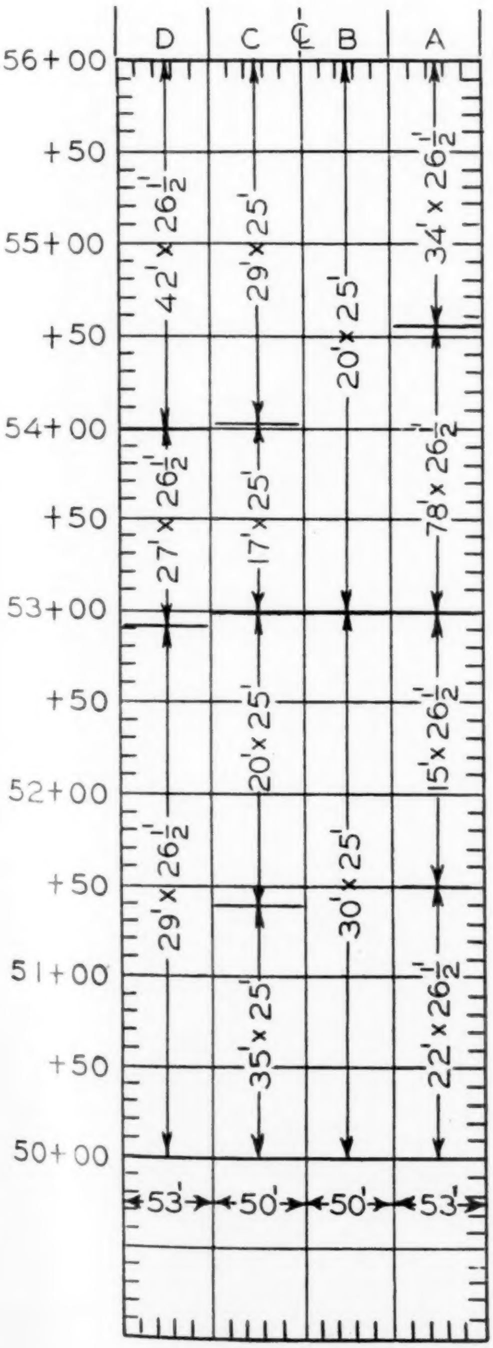
It will be seen from the above calculation that for a given width of spread the linear distance per load depends on the percentage of binder soil in the mixture and the moisture content of the binder soil. Accordingly charts were constructed from which the distribution of the binder soil was determined graphically. The chart used when the width of spread was 25 feet is shown in figure 19.

FEDERAL WORKS AGENCY
PUBLIC ROADS ADMINISTRATION
Washington, D.C.

Stabilization Record - Washington National Airport

Location NORTH - SOUTH RUNWAY

Date MAY 9, 1940



To - Superintendent of Stabilization
From - Inspector (P.R.A.)

Subject - Binder soil distribution.

The area indicated on sketch by .... is in condition to receive binder soil type BS-21 from pit located in upland area ROACHES RUN .... and shall be distributed as follows:

Sta.	to Sta.	Strip	Quantity in lbs. per sq.yd.	Lineal feet per load for width of 25' & 26½'
50+00	56+00	A B C D	VARIABLE	SEE SKETCH

FIGURE 20.—INSTRUCTION SHEET FOR DISTRIBUTION OF BINDER SOIL.

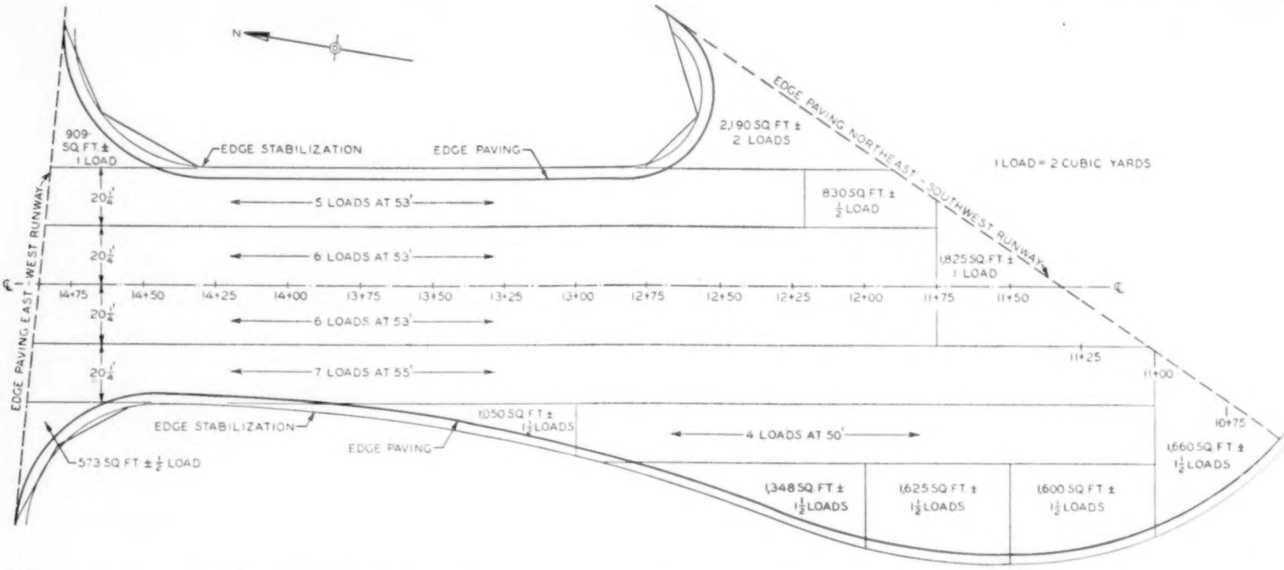


FIGURE 21.—BINDER SOIL DISTRIBUTION SHEET FOR TAXISTRIP NO. 6, SECTION 1.

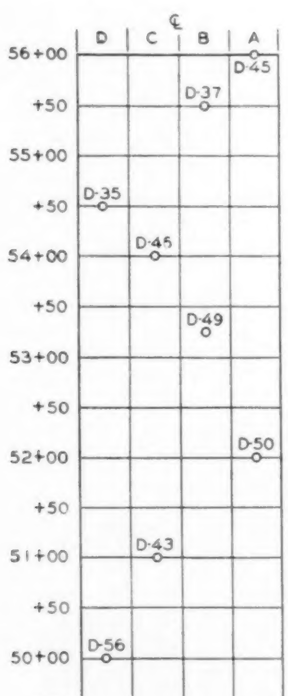


FIGURE 22.—PLAN OF LOCATIONS AT WHICH DENSITY SAMPLES WERE TAKEN.

Figure 20 is an example of the sheet furnished to the superintendent of stabilization showing the dimensions of the area for each load of binder soil to be placed on different parts of the runway. In runway or taxiway sections of irregular shape, a binder soil distribution sheet such as that shown in figure 21 was issued to the superintendent. Under these conditions, the application of binder soil was made to the nearest ½ load or 1 cubic yard.

MOTOR OIL USED IN DENSITY DETERMINATIONS

The locations where density tests were made depended on the order in which different areas were completed. A typical pattern is shown in figure 22. The test procedure used on this project was as follows:

A soil collecting tray, 15 inches square, having a 4½-inch circular opening in the center was set in place on the leveled surface (fig. 23–A) and a hole was dug through the compacted base by loosening the material with a trowel or pointed bar. The loosened material was scooped out with a large spoon, placed in a pail, and weighed on a spring scale of 30 pounds capacity (fig. 23–B). The indicator on the scale was adjusted for the weight of the pail so that the weight of the material removed from the hole was read directly. The moisture content of this material was then determined in the laboratory.

The circular opening in the tray served as a template for digging the hole while the tray itself collected the loosened material which tended to scatter during the digging, together with any that might have spilled from the spoon in transferring the material from the hole to the pail.

After all the loosened material had been removed, the hole was filled with motor oil (S. A. E. 40) from a 3-gallon can (fig. 23–C) and the can plus the oil remaining in it after filling the hole was weighed (fig. 24). The weight of the can plus the original volume of oil had been previously determined. The difference between the two weights gave the weight of oil in the hole. A hand suction pump was used to remove the oil from the hole.

The volume of the hole was then determined by dividing the weight of the oil in the hole by the known weight of 56 pounds per cubic foot of oil.

The density of the base course in pounds per cubic foot as compacted in the moist condition was calculated by the formula:

$$\text{Wet density} = \frac{\text{weight of moist material removed from hole}}{\text{volume of hole}}.$$

(*Continued on p. 191*)

LIGNIN BINDER USED IN TEST SECTIONS SUBJECTED TO ACCELERATED TRAFFIC

BY THE DIVISION OF TESTS, PUBLIC ROADS ADMINISTRATION

Reported by EDWARD A. WILLIS, Associate Highway Engineer, and RICHARD C. LINDBERG, Junior Highway Engineer

An investigation is reported in which crusher-run limestone, granite, slag, and gravel were mixed with a binder soil and tested in an outdoor circular track. The mixtures were first tested without any form of surface application. They were then treated with lignin binder and the tests continued. Finally, they were tested as base courses under a thin bituminous surface treatment.

Tests with distributed traffic prior to the application of lignin binder showed that an admixture of 10 percent of hydrated lime, which was present in two sections, improved the performance of both the granite-soil mixture and the gravel-soil mixture as surface courses. Under the same test conditions, the other four sections which had no chemical admixture showed signs of raveling under prolonged traffic.

The application of lignin binder at the rate of ½ gallon per square yard tended to cause softening and instability for a time. This condition gradually improved as traffic was continued. Thereafter the sections remained stable; and although the lignin did not prevent raveling, it did retard raveling as compared with tests on the untreated sections.

All sections gave good performance when tested under normal conditions of moisture as base courses for a thin bituminous surface treatment. Under extreme conditions the two sections containing granite became unstable. The lignin binder which was present while the materials were being tested as base courses did not alter the performance, either adversely or beneficially, from that which was anticipated from laboratory tests prior to the addition of the lignin binder.

LIGNIN BINDER, a by-product in the manufacture of paper from wood by the sulfite process, has been used, at least experimentally, in road construction for many years.[1] Since 1936, this sulfite liquor, marketed under a trade name, has been used by several of the State highway departments for the treatment of gravel surfaces and base courses.

This report is the fifth in a series describing investigations of materials for surface and base course construction. Former reports discussed laboratory tests and accelerated tests on a circular track of sand-clay, sand-clay-gravel, nonplastic granular materials with admixtures of water-retentive chemicals, and chert-gravel.

The present report describes similar investigations in which crusher-run materials—limestone, granite, slag, and gravel—were mixed with a binder-soil and tested in an outdoor circular track.

The circular track used in these investigations was the same as that used in the studies of water-retentive chemicals as admixtures with nonplastic roadbuilding materials, which have been reported previously.[2] The tire equipment was 30 inches by 5 inches of the high-pressure type inflated to a pressure of 80 pounds per square inch. The load on each wheel was 800 pounds during the entire test.

Distributed traffic was obtained by means of a mechanical device which gradually shifted the rotating beam with respect to its axis of rotation. Concentrated traffic was used in testing the materials after the surface treatment had been constructed. This was obtained by locking the sliding pivot of the beam in such a position that the wheels pursued two concentric circular courses having centerlines about 2½ inches on each side of the centerlines of the test sections.

SIX SECTIONS TESTED IN CIRCULAR TRACK

Six sections were tested in this investigation. Each section was 18 inches wide, 6 inches deep, and approximately 6.3 feet long. All the test sections were laid over a porous, crushed-stone subbase through which water introduced from below could pass.

Three different kinds of crusher-run aggregate (limestone, slag, granite) and crushed Potomac River gravel were used as coarse material in the test sections. The binder soil used was a local clay having a liquid limit of 41 and a plasticity index of 18. Two of the sections, Nos. 5 and 6, had 10 percent by weight of hydrated lime combined with the soil-aggregate mixtures.

The compositions of the six sections are shown in table 1. Thus, for example, section 1 contained 90 percent by weight of limestone screenings and 10 percent by weight of binder soil. Section 5 was identical with section 2 except for the admixture of 10 percent by weight of hydrated lime, and section 6 was like section 4 except for the addition of 10 percent of hydrated lime.

The gradings and soil constants of the mixtures used are given in table 2. The effect of the hydrated lime admixture in increasing

TABLE 1.—*Composition of sections*

Section No.	1	2	3	4	5	6
	Percent [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]
Granite		92			92	
Slag			80			
Limestone	90					
Gravel				85		85
Binder soil	10	8	20	15	8	15
Total	100	100	100	100	100	100
Hydrated lime					10	10

[1] Percentage based on dry weight.

TABLE 2.—*Gradings and soil constants of mixtures used in the track*

Section No.	1	2	3	4	5	6
Grading:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Passing ¾-inch sieve	100	100	100	100	100	100
Passing ⅜-inch sieve	100	100	98	94	100	94
Passing No. 4 sieve	98	96	78	70	96	72
Passing No. 10 sieve	65	69	54	56	68	52
Passing No. 40 sieve	34	48	37	38	46	35
Passing No. 200 sieve	21	22	23	19	22	17
Dust Ratio [1]	62	46	62	50	48	49
Tests on material passing No. 40 sieve:						
Liquid limit	19	24	25	20	29	27
Plasticity index	5	2	7	5	2	5

[1] $\text{Dust ratio} = 100 \frac{\text{Percentage passing No. 200 sieve}}{\text{Percentage passing No. 40 sieve}}$.

[1] Dust Preventives and Road Binders, by Prevost Hubbard. John Wiley and Sons, New York, 1910.

[2] Studies of Water-Retentive Chemicals as Admixtures with Nonplastic Road-Building Materials, by E. A. Willis and C. A. Carpenter, PUBLIC ROADS, vol. 20, No. 9, Nov. 1939.

the liquid limit can be seen by comparing the analysis of section 5 with that of section 2 and section 6 with that of section 4.

The circular track tests were divided into three parts. The mixtures were first tested without any form of surface application. They were then treated with lignin binder and the tests continued. Finally, they were tested as base courses under a thin bituminous surface treatment.

The procedure for preparing the materials for the track tests, constructing the test sections, applying waste sulfite liquor, and surface treating, was as follows:

1. The aggregates were proportioned by weight from stock piles and were thoroughly mixed before any water was added.

2. Hydrated lime was added to the materials for sections 5 and 6 and thoroughly mixed before wetting.

3. Water was then added in amount sufficient to cause the mixture to make a firm ball when squeezed in the hand and mixing continued to distribute the moisture uniformly.

4. The moistened mixtures were placed in the trough of the track in two approximately equal layers, each layer being compacted with pneumatic-tired traffic uniformly distributed over the surface. Material was added to the top lift of each section as compaction took place until the surface of the base course was from ½ inch to 1 inch below the curbs.

5. Compaction with distributed traffic was continued on the top layer for 40,000 wheel-trips. At this time all of the sections showed some corrugation and raveling. Section 3 had only a slight amount of corrugation and section 6 had the least of all.

6. The sections were trimmed smooth to a level 1 inch below the top of the curbs. It was necessary to add more material to sections 1 and 4 to bring them up to the desired level. This was done by lightly scarifying the compacted surface, placing additional material and hand tamping. Two thousand six hundred wheel-trips of distributed traffic were used to compact this material.

7. The sections were then tested without any form of surface treatment but with different ground water elevations; 160,000 wheel-trips of distributed traffic were applied to the materials in this first phase of the testing.

8. An application of a commercial grade of waste sulfite liquor at the rate of ½ gallon per square yard was made on the reshaped sections at the conclusion of the previous part of the test. The liquor contained 46 percent solids as received and was diluted with an equal part of water before it was applied.

9. After application of the waste sulfite liquor and compaction by 6,200 wheel-trips of distributed traffic, 100,000 wheel-trips of distributed traffic were applied, with different ground water elevations. This comprised the second phase of the testing procedure.

10. High places in the sections were leveled off and all loose material was removed preparatory to the application of a surface treatment.

11. A light tar prime was applied at the rate of 0.2 gallon per square yard and allowed to cure.

12. A surface treatment of 0.4 gallon of hot application bituminous material and a cover of 50 pounds per square yard of ¾-inch maximum size stone was applied.

13. The treatment was consolidated by additional distributed traffic until the surface was well sealed and showed no movement.

14. Concentrated traffic in the amount of 160,000 wheel-trips was then applied while the water elevation in the trough was varied. This was the third and final phase of circular track tests.

BEHAVIOR OF TEST SECTIONS JUDGED BY APPEARANCE AND DISPLACEMENT

The behavior of the materials being investigated was judged on the basis of the appearance of the sections at various stages of the tests, supplemented by measurements of vertical displacements of the surface. The measurements were made with the transverse [3] and longitudinal [4] profilometers which have been described in previous reports.

The schedule of traffic applications and changes in water elevation with notations on the behavior of the six test sections are shown in table 3. The average vertical displacements measured by the transverse and longitudinal profilometers are shown in figures 1 and 2. Initial profile measurements were taken at the beginning of each of the three phases of testing after apparently complete compaction by distributed traffic had been obtained. Changes in the behavior of the various sections under altered test conditions are shown by changes in the slopes of the displacement curves.

All of the sections compacted well initially. At the conclusion of the first compaction period (42,600 wheel-trips) water was admitted until its level was 1 inch above the top of the subbase. Initial profiles were taken at this time and traffic resumed. Less than 3,000 wheel-trips of traffic caused section 2, composed of granite and soil, to become soft and unstable. The section was consequently reshaped, tamped, and sprinkled but little benefit was noted. From time to time it was necessary to add to section 2 to replace material pushed over the curbs.

At this time the other sections were in good condition. At 70,000 wheel-trips section 5, which was similar to section 2 except for the addition of hydrated lime, began to develop a soft spot which later (82,600 wheel-trips) had to be filled with additional material. At 80,000 wheel-trips section 3, composed of slag and binder soil, began to shove but this condition had ceased by the time profiles were taken at 82,600 wheel-trips. So much raveling and movement had taken place in section 2 that the profile trace would not fall upon the profile paper used in the measurements of displacement. Sections 3 and 5 had also worn so badly it was necessary to add material to them. The remaining sections were in good condition at this time.

Traffic was continued under the same conditions for an additional 20,000 wheel-trips. Section 2 required sprinkling to keep the surface knit together, and it was necessary to rake material from the curbs to the center of the section. This was also necessary in section 3 where it adjoined section 2. Profiles were taken at 102,600 wheel-trips, or at the end of 60,000 wheel-trips with water 1 inch above the top of the subbase. Profiles taken at this time of sections 2, 3, and 5 were not truly representative of actual wear and displacement because of the material added to prevent jarring of the beam.

Distributed traffic was continued with the water level 1 inch below the top of the subbase. Section 2 improved somewhat during this time as regards stability

[3] Circular Track Tests on Low-Cost Bituminous Mixtures, by C. A. Carpenter and J. F. Goode, PUBLIC ROADS, vol. 17, No. 4, June 1936.

[4] A study of Sand-Clay-Gravel Materials for Base Course Construction, by C. A. Carpenter and E. A. Willis, PUBLIC ROADS, vol. 20, No. 1, March 1939.

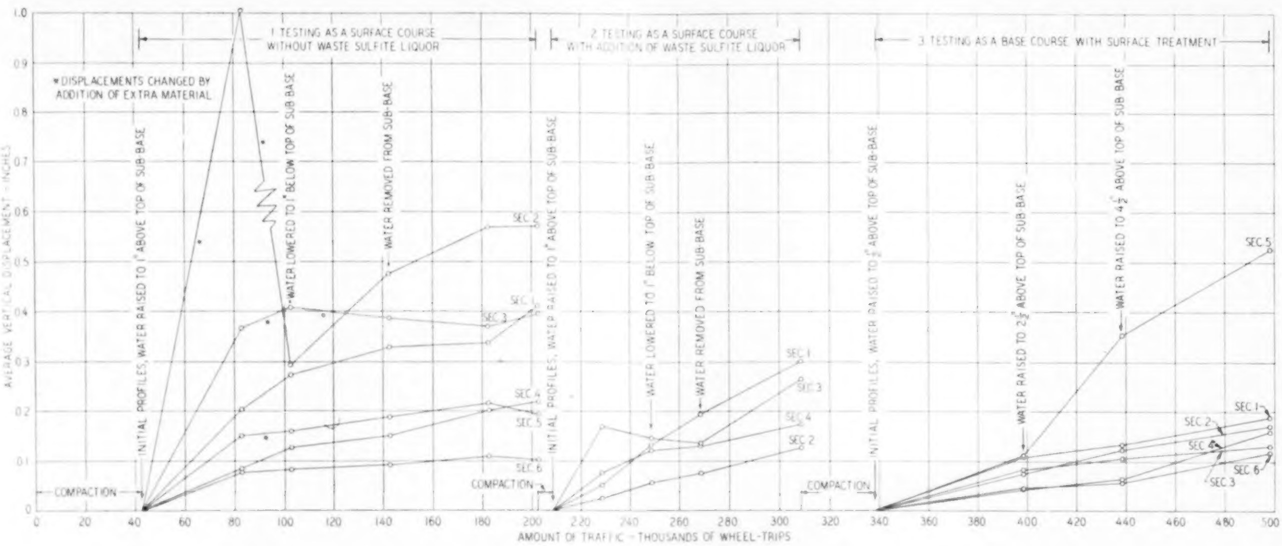


FIGURE 1.—RATE OF SURFACE DISPLACEMENT, TRANSVERSE MEASUREMENTS.

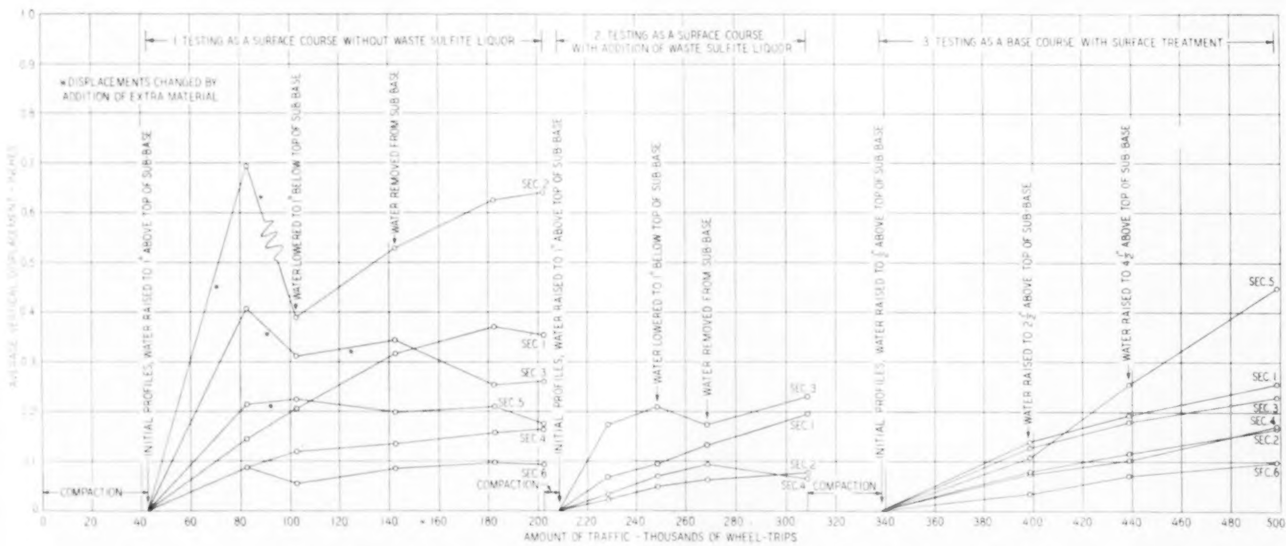


FIGURE 2.—RATE OF SURFACE DISPLACEMENT, LONGITUDINAL MEASUREMENTS.

but raveling of the surface was observed. When profiles were taken at 142,600 wheel-trips, sections 2 and 3 showed the most displacement and sections 4 and 6 the least.

Distributed traffic was continued with the water completely removed from the subbase. During the testing period, from 142,600 to 202,600 wheel-trips, there was a general improvement in the appearance of all the sections although the displacement as measured by the profilometers continued to increase with few exceptions.

Visual inspection and the profiles showed that section 2 had suffered the greatest displacement and wear, much loose material being present on the surface. Section 1, consisting of limestone and binder soil, showed some corrugation but underneath the loose surface the material was well knit together. Sections 3 and 4, composed of slag and binder soil and gravel and binder soil, respectively, were not unduly loose on the surface. Sections 5 and 6, both of which contained hydrated lime, were in the best condition.

The appearance of the sections after 202,600 wheel-trips is shown by the photographs in figure 3. Corrugations in section 1 are shown in figure 3–A; beneath the loose material the section was firm. The extremely loose condition of the surface of section 2 is shown in figure 3–B. The condition of sections 3 and 4 at the end of this phase of the testing is illustrated by figure 3–C. Figure 3–D shows section 6 and is representative of both sections 5 and 6. This photograph shows the hard, plaster-like appearance of the surface in many parts of these two sections which had been treated with hydrated lime. Loose material had been swept away from a part of the surface shown near the center of the photograph.

WASTE SULFITE LIQUOR APPLIED AS SURFACE TREATMENT

In the second phase of the tests (see table 3) waste sulfite liquor was applied to the surface of the sections at the rate of ½ gallon per square yard. Testing with distributed traffic was then continued.

TABLE 3.—*Schedule of operations and behavior of test sections*

Operation	Traffic	Water level above top of subbase	Behavior					
			Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
	Wheels trips	*Inches*						
Placing and compacting	0– [1] 42,600	[2] 0	Raveling	Some raveling	Some raveling	Raveling	Some raveling	Good.
1. Testing as surface course, without waste sulfite liquor	42,600– 82,600	1	Good	Unstable [4]	Slightly unstable	Good	Slightly unstable	Do.
Do	82,600– 102,600	1	do	Raveling [4]	Some raveling [4]	Some raveling	Some raveling [4]	Do.
Do	102,600– 142,600	[3] −1	Some raveling	Some raveling	do	Good	Good	Do.
Do	142,600– 182,600	[2] 0	do	Raveling	do	Some raveling	do	Do.
Do	182,600– 202,600	[2] 0	do	do	do	do	do	Do.
Compaction of surface after treatment with waste sulfite liquor	202,600– 208,800	[2] 0	Good	Good	Unstable	Good	Unstable	Unstable.
2. Testing as surface course with addition of waste sulfite liquor	208,800– 228,800	1	do	Slightly unstable [4]	Good [4]	Slightly unstable	do.[5]	Do.[5]
Do	228,800– 248,800	1	do	Good	do	do	Good	Good.
Do	248,800– 268,800	[3] −1	do	do	do	Good	do	Do.
Do	268,800– 308,800	[2] 0	Some raveling	Raveling	Raveling	do	do	Do.
Compacting surface treatment	308,800– 338,800	[2] 0	Good	Good	Good	do	do	Do.
3. Testing with concentrated traffic as a base course, waste sulfite liquor still present	338,800– 398,800	½	do	do	do	do	do	Do.
Do	398,800– 438,800	2½	do	do	do	do	Slightly unstable	Do.
Do	438,800– 498,800	4½	do	Slightly unstable	do	do	Failed	Do.

[1] 2,600 wheel-trips to compact additional material in sections 1 and 4.
[2] No water in subbase.
[3] Water level 1 inch below top of subbase.
[4] Necessary to add material to prevent jarring of the beam.
[5] Unstable at start but gradually improved after scarifying during second phase of testing.

In applying the lignin binder, the sections first were scarified to about 2 inches below the curbs and more material was added until the loose material was about ½ inch above the curbs. After the sections had been lightly sprinkled, waste sulfite liquor was applied at the rate of ½ gallon per square yard to the loose, uncompacted material. The attempt to apply traffic was unsuccessful as the rubber-tired wheels picked up the material and whipped it away.

Failure of this attempt at compaction resulted in trial of other means. All material was removed down to where the base was solid and firm, and new material was added. This material was tamped into place, lightly sprinkled with water, and allowed to dry overnight. Two hundred wheel-trips were used to compact the surface. Then waste sulfite liquor was applied at the rate of ½ gallon per square yard. After 48 hours, the treatment appeared to have penetrated thoroughly. Places where there seemingly was an excess of sulfite liquor had a shiny, slick surface much like a road on which excess bituminous material had been used. Figure 4 shows the appearance of the surface after the application of the waste sulfite liquor.

The water level was raised to 1 inch above the top of the subbase and distributed traffic was then continued. Two thousand wheel-trips were at slow speed and the 4,000 wheel-trips at regular speed. The lignin binder which had failed to penetrate in section 5 adhered to the tires when they passed over and was removed from the surface in this manner. At these places, the compacted material underneath was quite moist with capillary water. Section 6 started to break up at 205,150 wheel-trips and it was necessary to scarify and allow the loosened material to dry before resuming traffic.

In section 5 wherever there was a skin of surplus liquor on the surface, the base beneath was very moist and the same scarifying treatment was given this section as well. Water was withdrawn from the subbase during the drying period. After drying, the material in both sections was replaced and tamped firmly. Section 3 was showing signs of movement at this time but it was not deemed necessary to scarify this material.

At 208,800 wheel-trips, initial profiles for the second phase of the tests were taken of sections 1 to 4. Sections 5 and 6 were so unstable that no attempt was made to measure their displacements. Distributed traffic was continued. At 216,200 wheel-trips, section 4 developed a soft spot which increased in size. Sections 1, 2, and 3 were in good condition. Sections 5 and 6, which were unstable at the start of the second phase of testing, had improved and were very stable.

At 248,800 wheel-trips, the water level was dropped to 1 inch below the top of the subbase and traffic resumed. At this time all sections were in good condition. The waste sulfite liquor treatment had a tendency to scale off in sections 1 and 3. There appeared to be very little penetration of the material.

After withdrawal of water from the subbase at 268,800 wheel-trips distributed traffic was resumed. Sections 1, 2, and 3 showed signs of raveling, particularly section 3, at the completion of 40,000 wheel-trips without water in the subbase. The other three sections were in good condition.

At the conclusion of the second phase of the testing at 308,800 wheel-trips, all loose material was swept from the surface and all high places were leveled off. A light tar prime was applied at the rate of 0.2 gallon per square yard and a thin bituminous surface treatment consisting of 0.4 gallon of hot application bituminous material and 50 pounds of ¾-inch maximum size stone per square yard was constructed. Compaction of the surface treatment was accomplished with 30,000 wheel-trips of distributed traffic. Sections 5 and 6, which had been particularly unstable at the start of the previous phase of the investigation, were now tested as base courses without any changes in their composition.

The performance of the sections as bases is best shown by the displacement curves, figures 1 and 2. Section 5, composed of granite, soil, and hydrated lime, showed the greatest displacement of all the sections. It began to shove at about 418,800 wheel-trips with the water elevation at 2½ inches above the

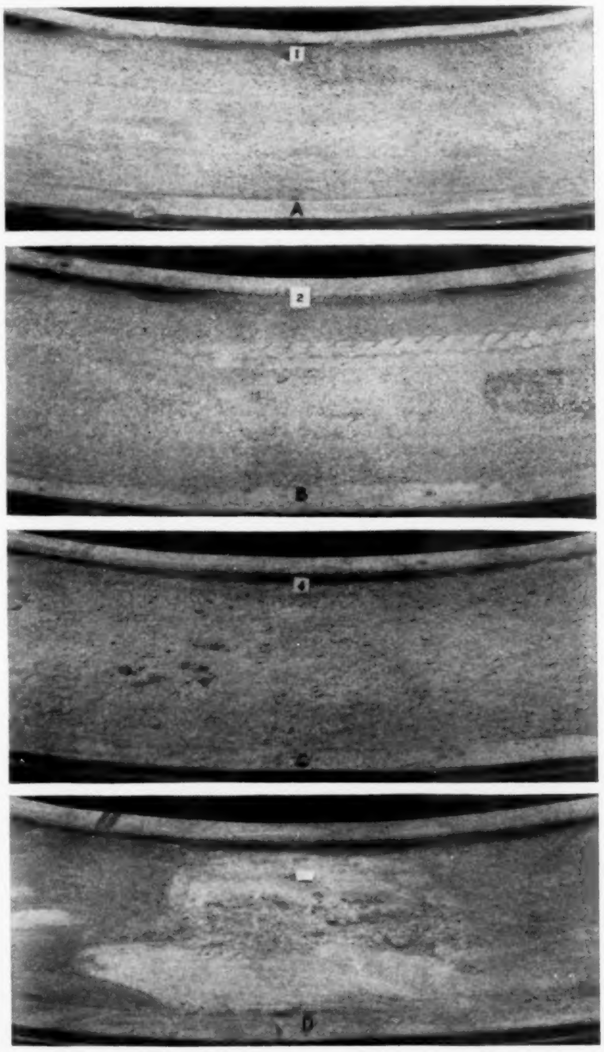


FIGURE 3.—APPEARANCE OF TEST SECTIONS AFTER 202,600 WHEEL-TRIPS OF DISTRIBUTED TRAFFIC ON THE UNTREATED MATERIAL. A, SECTION 1; B, SECTION 2; C, SECTION 4, WHICH IS ALSO REPRESENTATIVE OF THE APPEARANCE OF SECTION 3; AND D, SECTION 6, WHICH IS ALSO REPRESENTATIVE OF THE APPEARANCE OF SECTION 5.

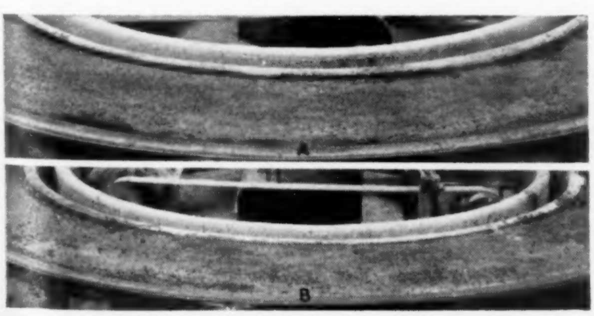


FIGURE 4.—APPEARANCE OF TEST SECTIONS AFTER APPLICATION OF WASTE SULFITE LIQUOR. A, SECTIONS 1, 2, AND 3 (FROM LEFT TO RIGHT); and B, SECTIONS 4, 5, AND 6.

top of the subbase. At 498,800 wheel-trips (the end of the test) section 5 had completely failed. At this same time section 2, composed of granite and soil, was shoving slightly under the wheels. Sections 1, 3, and 4 were in a satisfactory condition, and section 6, which had become unstable temporarily when tested with a treatment of waste sulfite liquor, was in the best condition of all the sections. Figure 5 shows the condition of the sections at the conclusion of the test.

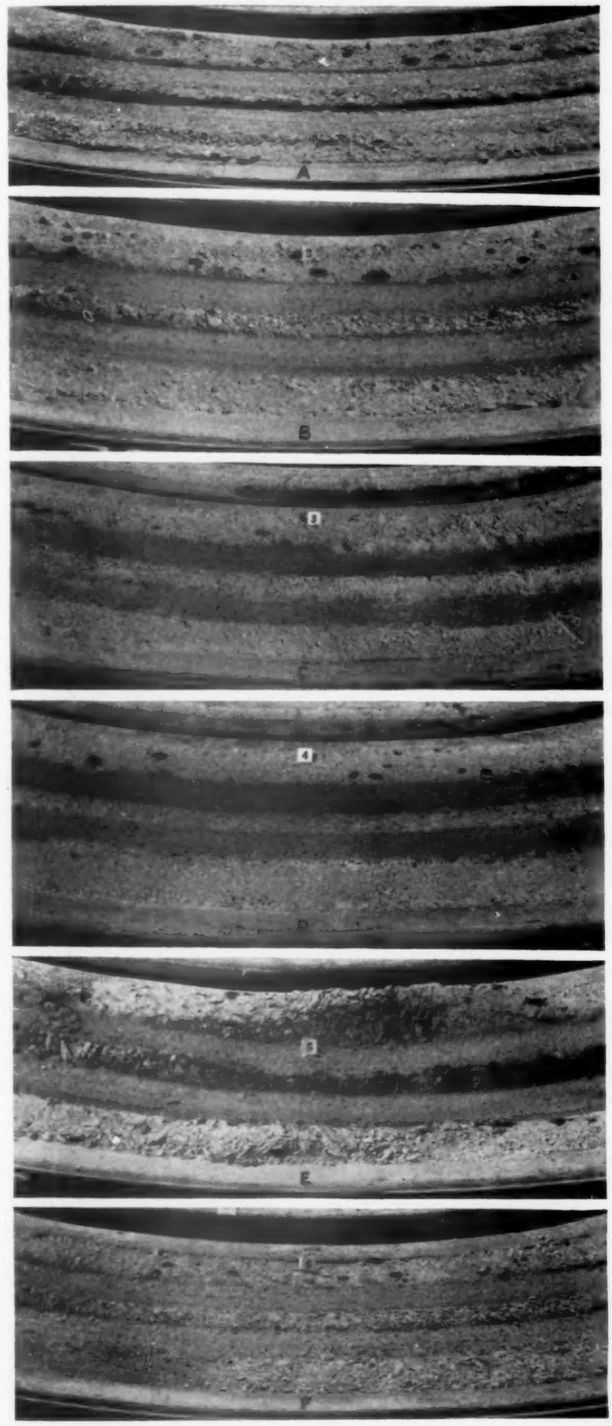


FIGURE 5.—APPEARANCE OF TEST SECTIONS AFTER 498,800 WHEEL-TRIPS. PICTURES A TO F CORRESPOND TO SECTIONS 1 TO 6, RESPECTIVELY.

At the conclusion of the track tests, samples were taken from each section for density and moisture content determinations. Table 4 shows the values obtained and also the volumetric composition of the samples.

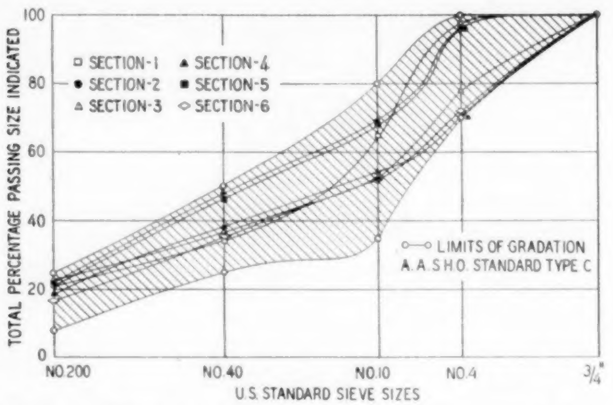


FIGURE 6.—GRADINGS OF MATERIALS USED IN TRACK TESTS.

The addition of hydrated lime reduced the density and also increased the moisture content of those mixtures in which it was present. Thus, the volumetric composition of section 2 was 81.9 percent solids, 10.9 percent water, and 7.2 percent air. The composition of section 5, which differed from section 2 only by the addition of 10 percent of hydrated lime, was 70.5 percent solids, 20.4 percent water, and 9.1 percent air. Similarly, section 4 had 83.3 percent solids while section 6, containing lime, had only 76.0 percent solids.

Section 1, consisting of limestone screenings and soil, had the highest density of any of the sections. The solids by volume of the sample from this section were 87.8 percent. Sections 2, 3, and 4 all had approximately the same density at the end of the test, as shown in table 4.

TABLE 4.—*Density of specimens taken from track at end of test*

Section No.	Density		Moisture	Composition by volume		
	Wet	Dry		Solids	Water	Air
	Lb. per cu. ft.	*Lb. per cu. ft.*	*Percent*	*Percent*	*Percent*	*Percent*
1	151.2	145.2	4.1	87.8	6.5	5.7
2	144.7	135.5	6.8	81.9	10.9	7.2
3	146.2	134.1	9.0	81.1	14.4	4.5
4	145.0	137.8	5.2	83.3	8.3	8.4
5	131.3	116.5	12.7	70.5	20.4	9.1
6	139.6	125.7	11.1	76.0	17.8	6.2

SUMMARY

The grading curves for the six combinations of materials tested are shown in figure 6. The shaded band in this figure is drawn to include the A. A. S. H. O. specification requirements for crusher-run (type C) surface-course materials. The grading requirements for the similar type of base-course materials are identical with those for surface courses.

The gradings of all the mixtures tested in the 6 sections of the track fall within the shaded band and, consequently, meet the grading requirements of the specifications.

The A. A. S. H. O. specifications for type C or crusher-run materials further stipulate that the fraction passing the No. 40 sieve shall have a liquid limit not greater than 35 and a plasticity index not less than 4 or more than 9 if the materials are to be used as surface courses, and that the same fraction shall have a liquid limit of not more than 25 and a plasticity index of not more than 3 if the materials are to be used as base courses. These specifictions also state the ratio of the fraction passing the No. 200 sieve to the fraction passing the No. 40 sieve shall be less than two-thirds for surface-course materials and less than one-half for base-course materials.

Consequently, sections 1, 3, 4, and 6 meet the requirements for surface-course materials only, the plasticity index being too high to conform to the specification limits for base course materials. Section 2 falls within the base but not the surface course requirements because it has a plasticity index of 2. Section 5 does not conform to the A. A. S. H. O. specifications for either base- or surface-course materials. The plasticity index of 2 is too low to meet the surface-course requirements and the liquid limit of 29 is too high to meet the base-course requirements.

Performance as surface courses.—The tests with distributed traffic prior to the application of lignin binder showed that the addition of 10 percent of hydrated lime improved the performance of both the granite-soil mixture (compare secs. 2 and 5) and the gravel-soil mixture (compare secs. 4 and 6) as surface courses.

Thus, the behavior of section 2, which was a mixture of 92 percent granite screenings and 8 percent binder-soil meeting the grading requirements but not the plasticity index requirements of the A. A. S. H. O., type C, surface-course material specifications, was definitely unsatisfactory throughout the first phase of the testing. The behavior of section 5, which differed in composition from section 2 only in the addition of 10 percent of hydrated lime, while inferior to some of the sections, was considerably better than that of section 2.

The gradings of the mixtures used in the two sections were almost identical and both had a plasticity index of 2. The appearance of the two sections after 202,600 wheel-trips and just before the application of the lignin binder is illustrated by figures 3–B and 3–D.

Section 4, consisting of a mixture of 85 percent river gravel and 15 percent binder soil, met all requirements for the A. A. S. H. O., type C, surface-course material specifications. Its behavior in the first phase of the track tests can be classed as fair. Some difficulty was experienced in getting this material to set up initially but thereafter, it remained stable although there was a tendency for the surface to loosen under prolonged testing with low water elevation (see fig. 3–C). Section 6 had the same composition as section 4 except for the addition of 10 percent of hydrated lime. The behavior of section 6 was excellent throughout the first phase of the testing (see table 3 and fig. 3–D).

Section 1 consisted of 90 percent limestone screenings and 10 percent binder soil. This mixture conformed to all requirements of the A. A. S. H. O. specification for type C, crusher-run surfacing materials. Its behavior like that of section 4 can be rated as fair. It was loose during the compaction period but finally set up and was stable under the applied loads. It tended to wear and become loose on top under continued traffic with low water elevation as shown in figure 3–A.

Section 3 consisted of 80 percent slag screenings and 20 percent binder soil. This mixture had a plasticity index of 7, the highest of any tested in this investigation. During the compaction period and while testing with water 1 inch above the top of the subbase, this section was unstable and exhibited considerable movement under traffic. When the water level was lowered, the stability of the section improved but wear on the surface was considerable.

(*Continued on p. 190*)

POSSIBLE SUBSTITUTES FOR ALUMINUM PAINT

By E. F. HICKSON, Chemist, National Bureau of Standards, and H. A. GARDNER, Chemical Engineer, The Institute of Paint and Varnish Research

Editor's note: As a result of the present need to conserve aluminum, the Office of Production Management has been giving attention to the uses of aluminum paint, including those in which the substitution of some other paint is entirely feasible and those in which a satisfactory substitution is difficult.

The Office of Production Management is endeavoring to allot a limited amount of aluminum powder and paste for those few uses where aluminum paint is deemed essential and where substitution is difficult. Therefore, each order for aluminum powder and paste for paint that is placed with the producing companies is reviewed on the basis of technical considerations regarding its use, and the material is released only for the most urgent defense purposes. Other protective and decorative coatings must be substituted in the majority of instances where aluminum paint has been employed in the past.

The Office of Production Management has requested the Public Roads Administration to bring this information to the attention of the administrative officials of the State highway departments.

As is the case with many other materials which are critical during the present National Emergency, such as tung oil, shellac, etc., we know of no one paint that has all the desirable properties of aluminum paint for special uses. We have in mind such properties as durability, visibility, low emissivity, impermeability to moisture, reflectivity, opacity, etc. For example, for certain specialized purposes, such as for aircraft use, where light weight, good reflectivity and good durability in sea water are necessary, as a heat-resisting paint (above 600° F.), as a coating for low-temperature (cold storage) and refrigeration plants, as an anti-bleeding, weather-resisting and light-colored coating for bituminous roofing, etc., it is difficult at the moment to suggest a universally satisfactory alternate for aluminum paint. There are, however, a number of types of paint which are available, and which if used for the particular purpose indicated, should prove satisfactory. It is with this in mind that the following recommendations are made:

Painting structural steel (bridges, tanks, etc.).—After priming the clean surface with a rust-resisting primer, such as red lead paint (F. S. TT–P–86),[1] basic lead chromate paint (F. S. TT–P–59) etc., use a finish coat (instead of aluminum) of gray paint (or any other tint) conforming to Federal Specification TT–P–36a or TT–P–156. If chalk-resistant titanium oxide is specified, Federal Specification TT–P–101a or War Department Cantonment Paint, Standard Specification 8000E, page 88, June 30, 1941, may also be used, tinted gray or any other desired color. If color is of no moment, dark-colored paints such as iron oxide (F. S. TT–P–31a) or black (F. S. TT–P–61) will be more durable than white or light-tint paints. The black and iron oxide paints will be just about as durable as aluminum paint. Additional information on painting structural steel may be found in National Bureau of Standards Letter Circular 422.

If light or heat reflectivity is the important factor, such as in the case of gasoline-storage tanks, then a white paint on a titanium-lead-zinc base (F. S. TT–P–101a) may be used. This is a durable paint, but not as durable as aluminum paint, but is said to be more efficient in preventing gas losses. Special proprietary "Tank White" paints have also been developed for this purpose.

Painting interiors; plaster walls and woodwork.—Use one coat of a primer and sealer, such as is covered by Federal Specification TT–P–56, followed by a coat of either eggshell flat wall paint (F. S. TT–P–51a) or gloss enamel (F. S. TT–E–506a).

Priming exterior wood.—For this purpose, for which aluminum paint has been used to some extent, use either Federal Specification TT–P–36a, TT–P–101a, TT–P–156, or one of the proprietary special undercoaters. One pint of linseed oil should be added to each gallon of the Federal Specification paints.

Sealing knots.—A thin coat of shellac varnish, a heavy coat of white lead paint, or one of the brands of special prepared paint undercoaters may be used.

Prevention of bleeding of bituminous coatings.—A good resin emulsion paint (F. S. TT–P–88) is suggested for interior use and has, in fact, been used successfully outdoors on Robertson (bituminous) protected metal. It prevents bleeding and serves as a primer.

Painting metal roofs.—On tin and other metal roofs where aluminum paint has been used increasingly of late, a good red metallic iron oxide roof paint (F. S. TT–P–31a) should be used. Red lead paint (F. S. TT–P–86) makes an excellent primer. Prepared metal paints made on a rust inhibitive pigment base well serve the purpose.

Painting smokestacks, boiler fronts, etc.—A good grade of black asphalt varnish (TT–V–51), a heat-resisting gray or black enamel, or certain of the proprietary heat-resisting compositions may be used.

Painting interior structural steel.—In industrial plants where good light reflection from the structural steel is desired, the following procedure may be used. Apply a priming coat of quick-drying red lead paint (Procurement Division Specification No. 358), followed by either two coats of eggshell flat white paint (F. S. TT–P–51a) or gloss white enamel, sometimes called "mill gloss white" (F. S. TT–E–506a). The enamel will be more water-resistant and more durable. For special conditions where fumes are encountered, such as in chemical laboratories, bakeries, tobacco factories, cafeterias, etc., a special enamel known as fume- and heat-resisting enamel (National Bureau of Standards Letter Circular 489) may be used.

Machinery and metal equipment.—A good machinery gray enamel (F. S. TT–E–506a) may be substituted in many instances.

Radiators and hot water piping.—The same paint used on the sidewalls may be used for this purpose. This may be eggshell flat wall paint (F. S. TT–P–51a) or white enamel (F. S. TT–E–506a). Where eggshell flat wall paint is used, we suggest the addition of one pint of interior varnish (F. S. TT–V–71a) to each gallon of the paint.

General considerations.—As can be seen from the foregoing, it is possible to use Federal Specification materials or their equivalents as substitutes for aluminum

[1] A table giving the complete designation of the Federal Specifications referred to herein will be found at the end of this article (p. 190).

paint under a variety of conditions. We have purposely avoided specifically recommending synthetic resin paints and enamels, because of the shortage of certain ingredients used in these paints. Similarly, certain highly durable cellulosic finishes could be employed, but the plasticizers and solvents for these are also developing an acute shortage.

Talc and mica-aluminum finishes.—In cases where it is believed essential to use some aluminum powder in order to produce an aluminum appearing finish, a great saving could be effected by employing mica or talc with the aluminum powder. As high as three parts by weight of mica or talc and one part by weight of aluminum powder may be stirred into a mixing varnish to produce a finish that has the characteristic aluminum appearance. This is in the proportion of two pounds of the total pigment (including the talc and aluminum powder) to one gallon of the mixing varnish. If the fine lining grade of aluminum powder (F. S. TT-A-476, Type B) is used, as little as ½ pound of it and ½ pound of mica, suitable for paint, may be mixed with 1 gallon of varnish (F. S. TT-V-81a) to produce a paint which is reported to have good durability.

Wherever Federal Specifications are referred to in this memorandum, they cover products which will be satisfactory for the usage referred to, but for the general buying public similar products may be obtained under trade brands at any paint store throughout the country. The paint dealer will readily recognize the material referred to.

Complete titles of Federal Specifications referred to in the body of the article:

Federal Specification No.—	*Title*
TT-P-86	Paint, Red Lead Base; Linseed-oil, Ready-Mixed.
TT-P-36a	Paints, Lead-Zinc Base, Ready-Mixed, and Semipaste, White and Tinted.
TT-P-156	Paint, White Lead Base; Basic Carbonate, Ready-Mixed, Light Tints and White.
TT-P-101a	Paint; Titanium-Zinc and Titanium-Zinc-Lead, Outside, Ready-Mixed, White.
TT-P-31a	Paints; Iron Hydroxide and Iron Oxide, Ready-Mixed and Semipaste.
TT-P-61	Paint; Ready-Mixed, and Semipaste, Black.
TT-P-56	Paint; (For) Priming Plaster Surfaces (Plaster Primer and Sealer).
TT-P-51a	Paints; Oil, Interior, Eggshell-Flat-Finish, Ready-Mixed and Semipaste, Light Tints and White.
TT-E-506a	Enamel; Interior, Gloss, Light Tints and White.
TT-V-51	Varnish, Asphalt.
TT-P-88	Paint, Paste, Resin Emulsion, Interior, Light Tints and White.
TT-V-71a	Varnish; Interior.
TT-V-81a	Varnish; Aluminum Mixing.
TT-P-59	Paint, International Orange.
TT-A-476	Aluminum-Powder (For) Paints (Aluminum-Bronze-Powder).

(Continued from p. 188)

Performance with surface application of lignin binder.—Sections 5 and 6, which contained hydrated lime and had given good service when tested as surface courses in the first phase of the investigation, became unstable when subjected to traffic after the application of lignin binder on the surface. They were so soft and shoved so badly that it was necessary to scarify them at 205,150 wheel-trips. After the mixtures had dried out and were recompacted, they gradually set up under traffic and by the end of the second phase of testing they were in satisfactory condition to receive a bituminous surface treatment.

Section 3, slag and binder soil, was also unstable during the compaction period after the application of the lignin binder. However, it was not necessary to scarify this section and its behavior gradually improved under continued traffic. Some raveling of the surface was noted toward the end of the second phase of the testing.

Section 2, granite and binder soil, was stable during the compaction period but when water was raised to 1 inch above the top of the subbase it showed a tendency to shove under traffic for a time. The condition gradually improved under continued traffic as shown in table 3. The behavior of section 4, gravel and soil binder, was similar to that of section 2.

Section 1, limestone and binder soil, remained in good condition throughout the entire period of testing after the application of the lignin binder except for slight raveling near the end of the second phase of the testing.

In general, the application of the diluted lignin binder tended to cause softening and instability under traffic for a time. This condition gradually improved as traffic was continued. Thereafter, the sections remained stable and while the lignin binder did not prevent raveling, it appeared to retard it somewhat as compared with the tests on untreated sections.

Performance as base courses.—All six sections gave good performance when tested as base courses for a thin bituminous surface treatment with water ½ inch above the top of the subbase. Previous investigations had shown that concentrated traffic with this ground water condition provides a condition sufficiently severe to identify the definitely unsatisfactory materials.

With the water elevation raised to 2½ inches above the top of the sub-base, section 5 (granite, soil, and hydrated lime) began to move under traffic and had failed completely at the end of the tests with the water 4½ inches above the top of the subbase (see fig. 5–E). Section 2, granite and soil, was also exhibiting considerable movement under the wheels at the end of the test although the displacements as measured by the profilometers were not excessive. The remaining four sections were in good condition throughout the third phase of the track investigations.

CONCLUSIONS

The following conclusions appear to be justified for the sections considered as surface courses without lignin binder treatment:

1. Mixtures of limestone screenings and soil (section 1), slag screenings and soil (sec. 3) and gravel and soil (sec. 4) meeting the requirements of the A. A. S. H. O. specifications for type C surface-course materials gave fair to good service when tested with distributed traffic.

2. The combination of granite screenings and binder soil (sec. 2) which met the grading but not the plasticity index requirements of the same specifications gave poor service.

3. The addition of 10 percent of hydrated lime improved the performance of both the granite-soil and the gravel-soil mixtures (secs. 5 and 6).

For the sections considered as surface courses after

treatment with lignin binder, the tests showed that:

4. The performance of section 2 was materially improved. Raveling was prevented for the duration of the tests in section 4 and was delayed to some extent in sections 1 and 3. Both sections 5 and 6, which contained hydrated lime, became soft and unstable but after scarifying and reworking the condition of these sections improved under traffic.

For the sections considered as base courses, it was found that:

5. All of the mixtures gave satisfactory service under normal conditions of moisture. Under extreme conditions, with the water elevation at 4½ inches above the top of the subbase, the two sections containing the granite screenings became unstable, section 5 which had the hydrated lime admixture failing completely. Previous investigations have indicated that this behavior could have been anticipated from the laboratory tests performed on the materials prior to the addition of lignin binder.

It is therefore concluded that the use of lignin binder in base courses under thin bituminous surface treatments does not affect the performance of base-course materials, either adversely or beneficially.

(Continued from p. 182)

Figure 23.—Three Steps in Making a Density Test: A, Removing Loosened Base Course Material from Hole; B, Weighing the Base Course Material Removed; and C, Filling Hole with Oil.

Figure 24.—By Determining the Weight of Oil Remaining in the Can, the Weight and Volume of Oil Required to Fill the Hole are Determined.

After the moisture content of the material removed from the hole was determined, the dry density of the base in pounds per cubic foot was computed by the formula:

$$\text{Dry density} = \frac{\text{wet density} \times 100}{\text{percentage of moisture} + 100}.$$

For a rapid calculation of the density in the field, the chart shown on figure 25 was used. In one of the tests, the weight of oil in the hole was 5.2 pounds, and the weight of moist material removed from the hole was 12.65 pounds. The weight of the oil is spotted on the chart at point A. This corresponds to a volume of 0.0929 cubic foot at point B.

A vertical line from point B intersects the curve corresponding to 12.65 pounds of moist material at point C. The wet density of 136.2 pounds per cubic

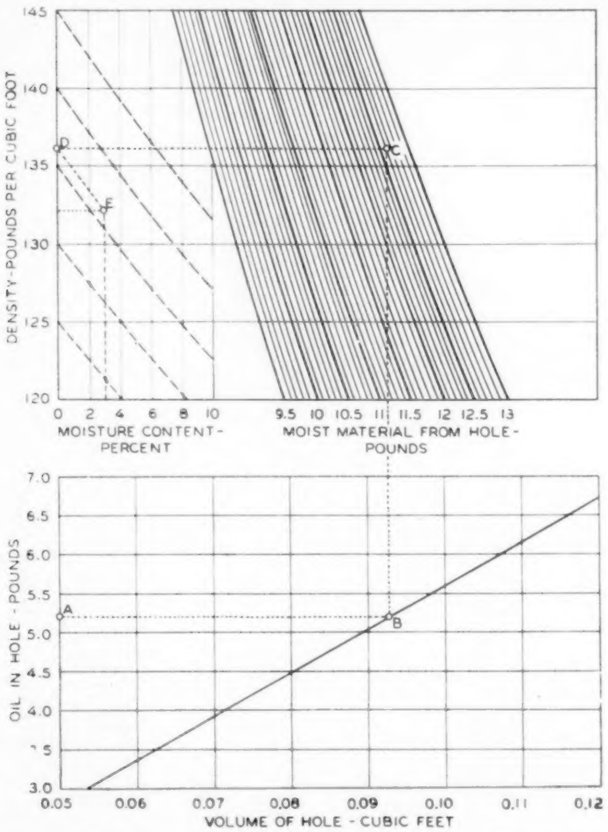


FIGURE 25.—GRAPHICAL CALCULATION OF DENSITY FROM TEST DATA

foot is indicated at point D on the density scale. With a moisture content of 3 percent the dry density of 132.2 pounds per cubic foot is found at point E. This chart was set up to cover the ranges in weights, volumes, and densities encountered on this particular project.

The sampling and testing in the portable field laboratory were performed by two trained operators with the aid of five laborers. The following is a list of the equipment used:

- 3 sets of sieves, each set consisting of pan and cover and sieves with square openings as follows: 3-inch, 2-inch, 1½-inch, 1-inch, ¾-inch, ⅜-inch, No. 4, No. 10, No. 40, No. 200.
- 4 No. 10 sieves.
- 4 No. 200 sieves.
- 3 No. 40 sieves.
- 1 metric solution balance, 5 kilograms capacity.
- 1 triple beam balance, 100 grams capacity.
- 4 double-burner gasoline camp stoves.
- 1 enameled pan, 10 inches diameter by 4 inches deep.
- 1 enameled pan, 14 inches diameter by 1½ inches deep.
- 6 enameled pans, 8 inches diameter by 1½ inches deep.
- 1 enameled pan, 6 inches diameter by 1½ inches deep.
- 24 tin pans, 11½ inches long, 8½ inches wide, 1½ inches deep.
- 1 pan brush, 2-inch diameter.
- 1 pan brush, 1-inch diameter.
- 2 brass wire brushes for sieves.
- 3 rubber-covered pestles.
- 2 iron pots, 10-inch diameter by 4 inches deep.
- 1 spoon, 12 inches long.
- 4 spoons, 14 inches long.
- 1 mason's trowel, 7 inches long.
- 1 Fahrenheit thermometer.
- 4 porcelain evaporating dishes, 3-inch diameter.
- 1 gasoline storage can, 5 gallons.
- 1 water storage tank, 30 gallons.
- 1 long handle shovel.
- 1 short handle shovel.
- 1 pick.
- 2 soil collecting trays for density tests.
- 1 spring scale, 30 pounds capacity.
- 1 oil can with spout, 3 gallons capacity.
- 1 tin pail, 2 gallons capacity.
- 1 grease suction pump.
- 1 garden trowel.
- 1 pointed bar, 1½-inch diameter, 30 inches long.
- 3 clip boards.
- 1 slide rule.
- 1 triangle.
- 1 water cooler and paper cups.
- Supply of canvas sample bags, tags, twine, pencils, notebooks, cross section paper, waste rags, towels, and laboratory forms.

In addition to the above, the laboratory was supplied with work tables, shelves, chairs, fire extinguishers, an office desk, and miscellaneous office supplies.

INDEX TO PUBLIC ROADS, VOLUME 21, NOW AVAILABLE

The index to PUBLIC ROADS, volume 21, is now available. A chronological list of articles and a list of authors are included with the index. The index will be sent free to subscribers to PUBLIC ROADS requesting it. Requests should be addressed to the Public Administration, Roads Federal Works Agency, Washington, D. C.

Indexes to volumes 6 to 8 and 10 to 20, inclusive, are also available and will be sent to PUBLIC ROADS subscribers upon request. Indexes to volumes 1 to 5, inclusive, have never been prepared. The supply of the index to volume 9 is exhausted.

DISPOSITION OF STATE MOTOR-FUEL TAX RECEIPTS - 1940

COMPILED FOR CALENDAR YEAR FROM REPORTS OF STATE AUTHORITIES

STATE	NET TOTAL RECEIPTS OF CALENDAR YEAR	ADJUSTMENTS DUE TO UNDISTRIBUTED FUNDS, ETC. 1/	NET TOTAL FUNDS DISTRIBUTED 2/	EXPENSES OF COLLECTION AND ADMINISTRATION	FOR OTHER ADMINISTRATIVE PURPOSES 3/	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE HIGHWAYS 4/	ON STATE PARK AND FOREST ROADS, ETC. 5/	STATE HIGHWAY POLICE	SERVICE OF STATE HIGHWAY OBLIGATIONS: STATE HIGHWAY BONDS AND NOTES	REIMBURSEMENT OBLIGATIONS 6/	TOTAL	TOTAL FOR STATE HIGHWAY PURPOSES 2/	FOR LOCAL ROADS AND STREETS: FOR WORK ON COUNTY AND LOCAL ROADS 4/ 7/	FOR WORK ON CITY STREETS 8/	SERVICE OF LOCAL HIGHWAY OBLIGATIONS	TOTAL	FOR NONHIGHWAY PURPOSES: TO GENERAL FUNDS 2/: INSPECTION FEES, DEALERS LICENSES, ETC.	MOTOR-FUEL TAX	FOR RELIEF OF UNEMPLOYMENT OR DESTITUTION	FOR EDUCATION	FOR OTHER PURPOSES 10/	TOTAL	STATE
	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	
ALABAMA	15,535	-73	15,462	6	63	6,298	12	-	1,141	-	1,141	7,451	7,785	125	-	7,910	-	-	-	-	-	-	ALABAMA
ARIZONA	4,769	-10	4,759	62	-	3,115	-	122	-	-	-	3,237	*1,660	-	-	1,660	-	-	-	-	-	-	ARIZONA
ARKANSAS	11,412	-	11,412	148	[illegible]	2,595	-	14	3,278	3,784	7,062	9,671	1,222	-	169	1,391	-	-	-	-	-	-	ARKANSAS
CALIFORNIA	51,978	-716	51,262	136	-	29,909	-	-	-	-	-	29,909	*14,121	1,013	-	15,134	-	-	4,825	-	-	4,825	CALIFORNIA
COLORADO	8,291	-37	8,254	[illegible]	25	4,133	-	124	1,081	-	1,081	5,338	2,172	-	-	2,172	-	-	-	-	-	1	COLORADO
CONNECTICUT	11,084	-370	10,714	[illegible]	-	9,067	-	-	-	1,603	1,603	10,670	-	-	-	-	-	-	-	-	-	-	CONNECTICUT
DELAWARE	2,325	-	2,325	3	-	4/ 1,669	-	184	143	301	444	2,297	(9/)	-	-	-	-	-	-	-	18	18	DELAWARE
FLORIDA	27,448	87	27,535	[illegible]	104	13,800	-	-	-	9,357	9,357	23,158	-	-	-	-	[illegible]	1,404	-	1,963	17	4,239	FLORIDA
GEORGIA	22,841	-7	22,834	684	-	14,583	-	-	83	-	83	14,666	3,668	-	-	3,668	29	-	-	3,781	6	3,816	GEORGIA
IDAHO	4,817	20	4,837	16	4	3,412	-	7	101	-	101	3,520	*1,297	-	-	1,297	-	-	-	-	-	-	IDAHO
ILLINOIS	41,824	-	41,824	208	312	12,594	-	-	-	-	-	12,594	9,998	10,337	1,595	21,930	132	-	4,462	2,167	-	6,782	ILLINOIS
INDIANA	26,068	-	26,068	90	108	13,933	-	695	-	-	-	14,628	8,794	1,096	-	9,890	455	887	-	-	-	1,352	INDIANA
IOWA	14,655	30	14,685	120	-	4,230	-	-	-	3,134	3,134	7,364	*6,993	8	-	7,001	-	-	-	-	-	-	IOWA
KANSAS	10,562	-	10,562	352	110	6,705	-	132	270	606	876	7,713	2,387	-	-	2,387	-	-	-	-	-	-	KANSAS
KENTUCKY	14,717	-536	14,181	42	-	12,265	-	222	-	-	-	12,487	1,652	-	-	1,652	-	-	-	-	-	-	KENTUCKY
LOUISIANA	18,671	-1,662	17,009	38	87	3,683	-	-	7,044	-	7,044	10,727	-	-	-	-	-	2,460	1,305	1,196	1,196	6,157	LOUISIANA
MAINE	5,929	-	5,929	11	-	3,381	-	190	1,655	-	1,655	5,226	692	-	-	692	-	-	-	-	-	-	MAINE
MARYLAND	11,448	-	11,448	28	-	6,555	-	-	-	-	-	6,555	881	3,363	-	4,244	-	-	-	-	-	-	MARYLAND
MASSACHUSETTS	21,454	-481	20,973	50	26	4,501	11/ 834	392	12/ 2,987	-	2,987	8,734	9,480	-	12/ 1,773	11,253	77	-	12/ 833	-	-	910	MASSACHUSETTS
MICHIGAN	32,398	9	32,407	313	-	21,561	-	-	4,081	-	4,081	25,642	*6,550	-	-	6,550	-	-	-	-	-	-	MICHIGAN
MINNESOTA	18,526	43	18,569	75	78	11,882	-	331	-	-	-	12,213	*6,106	-	-	6,106	102	-	-	-	-	102	MINNESOTA
MISSISSIPPI	11,931	10	11,941	123	49	2,875	13/ 479	-	3,523	-	3,523	6,827	*4,942	-	-	4,942	-	-	-	-	-	-	MISSISSIPPI
MISSOURI	13,455	-	13,455	62	55	7,832	-	405	4,908	105	5,013	13,250	-	-	-	-	88	-	-	-	-	88	MISSOURI
MONTANA	5,074	153	5,227	21	6	4,253	-	-	947	-	947	5,200	-	-	-	-	-	-	-	-	-	-	MONTANA
NEBRASKA	11,828	-25	11,803	88	46	5,518	-	-	-	-	-	5,518	*3,451	378	-	3,829	-	-	2,322	-	-	2,322	NEBRASKA
NEVADA	1,507	-	1,507	7	21	1,472	-	-	-	7	7	1,479	-	-	-	-	-	-	-	-	-	-	NEVADA
NEW HAMPSHIRE	3,617	-	3,617	(14/)	-	2,309	-	73	802	-	802	3,184	212	-	15/ 221	433	-	-	-	-	-	-	NEW HAMPSHIRE
NEW JERSEY	24,337	212	24,549	255	-	9,125	274	304	2,014	-	2,014	11,717	4,229	-	1,020	5,249	-	16/ 4,284	1,810	558	676	7,328	NEW JERSEY
NEW MEXICO	4,699	-	4,699	98	13	2,691	-	-	1,897	-	1,897	4,588	-	-	-	-	-	-	-	-	-	-	NEW MEXICO
NEW YORK 17/	73,116	-1,001	72,115	110	-	7,599	207	583	4,831	-	4,831	13,220	9,249	1,787	-	11,036	-	47,749	-	-	-	47,749	NEW YORK 17/
NORTH CAROLINA	27,372	-	27,372	30	105	4/ 19,347	-	-	6,528	229	6,757	26,104	(4/)	-	-	-	984	-	-	-	149	1,133	NORTH CAROLINA
NORTH DAKOTA	3,452	79	3,531	46	77	2,583	-	-	-	-	-	2,583	822	-	-	822	-	3	-	-	-	3	NORTH DAKOTA
OHIO	18/ 50,789	1,153	51,942	164	-	21,919	-	-	-	-	-	21,919	9,660	7,208	-	16,868	-	12,991	-	-	-	12,991	OHIO
OKLAHOMA	15,067	31	15,098	445	65	10,349	-	-	-	-	-	10,349	*3,269	738	-	4,007	232	-	-	-	-	232	OKLAHOMA
OREGON	11,345	-	11,345	43	-	7,118	-	259	2,031	8	2,039	9,416	*1,784	-	-	1,784	-	-	-	-	102	102	OREGON
PENNSYLVANIA	62,495	-	62,495	197	-	31,300	76	2,274	2,954	-	2,954	36,604	*9,949	-	-	9,949	-	15,662	-	-	83	15,745	PENNSYLVANIA
RHODE ISLAND 19/	3,945	-	3,945	14	-	1,372	7	132	140	-	140	1,551	32	-	-	32	-	2,248	-	-	-	2,248	RHODE ISLAND 19/
SOUTH CAROLINA	13,837	-	13,837	47	24	8,790	-	-	1,721	749	2,470	11,260	*2,267	22	-	2,289	217	-	-	-	-	217	SOUTH CAROLINA
SOUTH DAKOTA	4,511	-106	4,405	31	12	3,697	20	43	2	-	2	3,752	536	-	-	536	74	-	-	-	-	74	SOUTH DAKOTA
TENNESSEE	22,178	-361	21,817	321	43	4,541	23	-	2,848	680	3,528	8,092	5,930	-	-	5,930	1,208	-	-	-	6,223	7,431	TENNESSEE
TEXAS	47,530	-390	47,140	742	-	21,867	-	527	-	7,287	7,287	29,681	*5,131	-	-	5,131	-	-	-	11,586	-	11,586	TEXAS
UTAH	3,988	8	3,996	17	12	3,742	-	152	-	-	-	3,894	73	-	-	73	-	-	-	-	-	-	UTAH
VERMONT	2,781	-	2,781	2	-	1,060	4	-	376	-	376	1,440	987	-	337	1,324	-	-	-	-	15	15	VERMONT
VIRGINIA	19,394	60	19,454	-	30	4/ 18,558	-	325	138	-	138	19,021	4/ 320	74	-	394	-	-	-	-	9	9	VIRGINIA
WASHINGTON	17,185	-	17,185	49	-	6,972	-	-	17/ 127	50	177	7,149	*6,369	2,373	12/ 173	8,915	-	-	12/ 1,072	-	-	1,072	WASHINGTON
WEST VIRGINIA	10,691	-	10,691	15	-	4/ 5,906	-	-	4,770	-	4,770	10,676	(4/)	-	-	-	-	-	-	-	-	-	WEST VIRGINIA
WISCONSIN 20/	21,311	-	21,311	76	161	4,405	100	-	-	2,449	2,449	6,954	5,989	951	-	6,940	-	7,180	-	-	-	7,180	WISCONSIN 20/
WYOMING	2,720	-	2,720	13	-	1,905	-	43	65	-	65	2,018	689	-	-	689	-	-	-	-	-	-	WYOMING
DISTRICT OF COLUMBIA	3,229	3	3,232	(21/)	-	-	-	-	-	-	-	-	-	3,225	-	3,225	7	-	-	-	-	7	DISTRICT OF COLUMBIA
TOTAL	870,136	-3,877	866,259	5,784	1,539	408,936	2,036	7,569	64,936	28,599	93,535	512,146	160,648	36,399	5,909	202,956	3,961	95,389	14,679	21,211	8,494	143,734	TOTAL

1/ AMOUNTS DISTRIBUTED DURING THE CALENDAR YEAR OFTEN DIFFER FROM ACTUAL COLLECTIONS BECAUSE OF UNDISTRIBUTED FUNDS AND LAG BETWEEN ACCOUNTS OF COLLECTING AND EXPENDING AGENCIES.

2/ IN MANY STATES THE PROCEEDS OF HIGHWAY-USER TAXES ARE PLACED IN A COMMON FUND FROM WHICH A DISTRIBUTION IS MADE. THE AMOUNTS SO DISTRIBUTED HAVE BEEN PRORATED IN PROPORTION TO THE RECEIPTS NOT OTHERWISE DEDICATED. SEE TABLES MV-3 AND MC-2.

3/ WHERE REPORTED SEPARATELY FROM COLLECTION EXPENSES, FUNDS ALLOTTED FOR MOTOR-FUEL INSPECTION, ADMINISTRATION OF MOTOR VEHICLE DEPARTMENT, AND REGULATION OF MOTOR VEHICLES ARE SHOWN IN THIS COLUMN.

4/ THE FOLLOWING AMOUNTS FOR CONSTRUCTION AND MAINTENANCE OF COUNTY ROADS UNDER STATE CONTROL ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES: DELAWARE, $426,000; NORTH CAROLINA, $8,089,000; VIRGINIA, $7,759,000; WEST VIRGINIA, $2,135,000. THE THREE COUNTIES IN VIRGINIA WHICH HAVE COUNTY ROADS NOT UNDER STATE CONTROL RECEIVED $320,000.

5/ AMOUNTS DISTRIBUTED FOR STATE PARK AND FOREST ROADS, ETC. WERE LISTED SEPARATELY, RATHER THAN UNDER "STATE HIGHWAY PURPOSES", ON TABLE G-3 FOR 1939 AND PRIOR YEARS.

6/ REIMBURSEMENT TO COUNTIES AND LOCAL UNITS OF GOVERNMENT FOR AMOUNTS SPENT ON ROADS NOW ON STATE SYSTEM.

7/ IN STATES INDICATED BY STAR (*) LAW PROVIDES THAT THESE FUNDS MAY ALSO BE USED FOR SERVICE OF LOCAL HIGHWAY OBLIGATIONS. AMOUNTS SO USED NOT REPORTED SEPARATELY. IN COLORADO FUNDS MAY BE USED ON BOTH STATE AND LOCAL ROADS.

8/ THIS COLUMN SHOWS SPECIFIC ALLOTMENTS FOR CITY STREETS. WHERE REPORTED SEPARATELY, FUNDS ALLOTTED FOR URBAN EXTENSIONS OF STATE HIGHWAY SYSTEM ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES.

9/ TO STATE GENERAL FUNDS EXCEPT AS FOLLOWS: LOUISIANA, 1 CENT OF TAX TO PARISHES; WISCONSIN, $2,350,000 PAYMENT TO TOWNS, CITIES, AND VILLAGES IN LIEU OF PERSONAL PROPERTY TAX FORMERLY IMPOSED ON MOTOR VEHICLES. ALLOCATIONS TO COUNTY OR LOCAL GENERAL FUNDS MAY HAVE BEEN USED IN PART FOR HIGHWAYS, BUT SUCH AMOUNTS NOT REPORTED.

10/ FOR THE FOLLOWING PURPOSES: DELAWARE, STATE PARKS AND LANDS, MOSQUITO CONTROL, CCC DITCHING; FLORIDA, AVIATION; GEORGIA, INVESTIGATION OF WATER RESOURCES; LOUISIANA, HARBOR IMPROVEMENT; NEW JERSEY, DEBT SERVICE ON INSTITUTIONAL CONSTRUCTION BONDS, $271,000, BOARD OF COMMERCE AND NAVIGATION, $405,000; NORTH CAROLINA, STATE PROBATION AND PAROLE COMMISSIONS; OREGON, STATE PARKS; PENNSYLVANIA, AVIATION, $75,000, COOPERATIVE WORK OTHER DEPARTMENTS, $8,000; TENNESSEE, DEBT SERVICE ON NONHIGHWAY BONDS; VERMONT, DEBT SERVICE ON NONHIGHWAY PORTION OF FLOOD RELIEF BONDS; VIRGINIA, AVIATION.

11/ TO METROPOLITAN DISTRICT COMMISSION FOR PARKWAYS AND BOULEVARDS.

12/ INCLUDES DEBT SERVICE CHARGES ON EMERGENCY RELIEF BOND ISSUES, PRORATED IN PROPORTION TO USE OF PROCEEDS FOR STATE HIGHWAYS, LOCAL ROADS AND STREETS, AND NONHIGHWAY PURPOSES.

13/ TO GULF COAST COUNTIES FOR MAINTENANCE OF SEA WALL PROTECTING STATE HIGHWAYS.

14/ PAID OUT OF MOTOR-VEHICLE REVENUE, $4,000. SEE TABLE MV-3.

15/ INCLUDES $117,000 PAID ON HIGHWAY RELIEF BONDS ISSUED BY STATE FOR LOCAL ROADS, AND $104,000 ON PRO-RATA SHARE OF HIGHWAY FLOOD BONDS.

16/ INCLUDES $3,000,000 ORIGINALLY APPROPRIATED FOR RELIEF BUT LATER TRANSFERRED BY LEGISLATIVE ACTION TO STATE GENERAL FUND.

17/ APPROPRIATIONS FOR HIGHWAY PURPOSES OUT OF STATE GENERAL FUND HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

18/ TAX OF $638,000 ON NON-MOTOR-VEHICLE FUELS NOT INCLUDED.

19/ EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE STATE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

20/ MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES ARE PAID INTO HIGHWAY ACCOUNT OF STATE GENERAL FUND, AND ARE USED FOR ANY PURPOSE, INCLUDING HIGHWAYS. EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST RECEIPTS FROM MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES, PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS.

21/ PAID OUT OF GENERAL REVENUE. AMOUNT NOT REPORTED.

DISPOSITION OF STATE MOTOR-VEHICLE RECEIPTS - 1940

COMPILED FOR CALENDAR YEAR FROM REPORTS OF STATE AUTHORITIES

STATE	NET TOTAL RECEIPTS OF CALENDAR YEAR	ADJUSTMENTS DUE TO UNDISTRIBUTED FUNDS, ETC. 1/	NET TOTAL FUNDS DISTRIBUTED 2/	EXPENSES OF COLLECTION AND ADMINISTRATION 3/	FOR OTHER ADMINISTRATIVE PURPOSES 4/	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE HIGHWAYS 5/	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE PARK AND FOREST ROADS, ETC. 6/	FOR STATE HIGHWAY PURPOSES: STATE HIGHWAY POLICE	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: STATE HIGHWAY BONDS AND NOTES	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: REIMBURSEMENT OBLIGATIONS 7/	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: TOTAL	TOTAL FOR STATE HIGHWAY PURPOSES 6/	FOR LOCAL ROADS AND STREETS: FOR WORK ON COUNTY AND LOCAL ROADS 5/ 8/	FOR LOCAL ROADS AND STREETS: FOR WORK ON CITY STREETS 9/	FOR LOCAL ROADS AND STREETS: SERVICE OF LOCAL HIGHWAY OBLIGATIONS	FOR LOCAL ROADS AND STREETS: TOTAL	FOR NONHIGHWAY PURPOSES: TO GENERAL FUNDS 10/	FOR NONHIGHWAY PURPOSES: FOR RELIEF OF UNEMPLOYMENT OR DESTITUTION	FOR NONHIGHWAY PURPOSES: FOR EDUCATION	FOR NONHIGHWAY PURPOSES: FOR OTHER PURPOSES 11/	FOR NONHIGHWAY PURPOSES: TOTAL	STATE
	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	
ALABAMA	4,548	310	4,858	414	-	1,578	3	100	1,436	-	1,436	3,117	81	230	-	311	836	-	-	-	836	ALABAMA
ARIZONA	1,225	22	1,247	268	-	933	-	30	-	-	-	963	10	-	-	10	-	-	-	-	-	ARIZONA
ARKANSAS	3,399	386	3,785	92	-	897	-	177	1,896	687	2,583	3,657	-	-	35	35	-	-	-	-	-	ARKANSAS
CALIFORNIA	27,914	-699	27,215	3,445	35	4,205	-	2,950	3,695	-	3,695	10,850	*4,067	-	-	4,067	8,818	-	-	-	8,818	CALIFORNIA
COLORADO	2,797	2	2,799	565	-	798	-	49	308	-	308	1,155	1,079	-	-	1,079	-	-	-	-	-	COLORADO
CONNECTICUT	7,385	-171	7,214	898	-	2,053	-	793	-	361	361	3,207	3,109	-	-	3,109	-	-	-	-	-	CONNECTICUT
DELAWARE	1,252	-	1,252	148	-	5/ 796	-	88	68	143	211	1,095	(5/)	1	-	1	-	-	-	8	8	DELAWARE
FLORIDA	8,002	-	8,002	928	-	-	-	320	-	-	-	320	-	-	-	-	-	-	6,754	-	6,754	FLORIDA
GEORGIA	2,768	80	2,848	408	-	-	-	771	-	-	-	771	1,669	-	-	1,669	-	-	-	-	-	GEORGIA
IDAHO	1,401	28	1,429	65	-	173	-	99	-	-	-	272	*1,092	-	-	1,092	-	-	-	-	-	IDAHO
ILLINOIS	24,760	-103	24,657	1,641	-	9,676	-	1,658	9,960	-	9,960	21,294	1,609	-	-	1,609	113	-	-	-	113	ILLINOIS
INDIANA	10,596	-409	10,187	1,062	-	5,004	-	250	-	-	-	5,254	3,015	538	-	3,553	318	-	-	-	318	INDIANA
IOWA	12,987	7	12,994	605	-	6,256	-	402	-	4,931	4,931	11,589	787	13	-	800	-	-	-	-	-	IOWA
KANSAS	4,012	765	4,777	540	6	2,797	-	73	92	274	366	3,236	*995	-	-	995	-	-	-	-	-	KANSAS
KENTUCKY	5,509	-30	5,479	536	-	2,150	-	39	-	-	-	2,189	917	-	-	917	1,837	-	-	-	1,837	KENTUCKY
LOUISIANA	5,392	20	5,412	130	-	4,612	-	500	170	-	170	5,282	-	-	-	-	-	-	-	-	-	LOUISIANA
MAINE	4,162	235	4,397	270	-	2,227	-	177	1,115	-	1,115	3,519	466	-	-	466	142	-	-	-	142	MAINE
MARYLAND	6,698	-	6,698	356	49	2,573	-	442	783	-	783	3,798	-	1,160	-	1,160	1,335	-	-	-	1,335	MARYLAND
MASSACHUSETTS	7,319	162	7,481	1,568	70	1,261	12/ 239	110	13/ 836	-	836	2,446	2,654	-	13/ 496	3,150	-	13/ 247	-	-	247	MASSACHUSETTS
MICHIGAN	24,115	372	24,487	1,979	-	340	-	651	-	-	-	991	*21,517	-	-	21,517	-	-	-	-	-	MICHIGAN
MINNESOTA	10,305	-294	10,011	590	-	4,867	-	136	2,667	1,606	4,273	9,276	-	-	-	-	145	-	-	-	145	MINNESOTA
MISSISSIPPI	3,009	80	3,089	188	-	104	-	242	-	-	-	346	*2,555	-	-	2,555	-	-	-	-	-	MISSISSIPPI
MISSOURI	10,750	-6	10,744	555	-	6,022	-	311	3,774	82	3,856	10,189	-	-	-	-	-	-	-	-	-	MISSOURI
MONTANA	1,721	76	1,797	64	-	-	-	248	-	-	-	248	1,441	44	-	1,485	-	-	-	-	-	MONTANA
NEBRASKA	2,839	-20	2,819	248	13	717	-	157	-	-	-	874	1,684	-	-	1,684	-	-	-	-	-	NEBRASKA
NEVADA	313	-10	303	30	-	167	-	25	81	-	81	273	-	-	-	-	-	-	-	-	-	NEVADA
NEW HAMPSHIRE	3,052	-	3,052	151	4	2,429	-	120	2	-	2	2,551	173	-	14/ 173	346	-	-	-	-	-	NEW HAMPSHIRE
NEW JERSEY	22,562	122	22,684	2,207	-	8,775	263	293	1,937	-	1,937	11,268	4,466	-	981	5,447	1,235	1,741	537	649	4,162	NEW JERSEY
NEW MEXICO	1,994	1	1,995	181	126	664	-	141	-	-	-	805	231	36	-	267	616	-	-	-	616	NEW MEXICO
NEW YORK 15/	55,944	-946	54,998	2,965	194	10,994	299	844	6,988	-	6,988	19,125	*11,145	5,336	-	16,481	16,233	-	-	-	16,233	NEW YORK 15/
NORTH CAROLINA	8,174	382	8,556	546	-	5/ 5,531	-	547	1,866	66	1,932	8,010	(5/)	-	-	-	-	-	-	-	-	NORTH CAROLINA
NORTH DAKOTA	1,661	-21	1,640	92	-	817	-	14	-	-	-	831	717	-	-	717	-	-	-	-	-	NORTH DAKOTA
OHIO	30,376	-2,143	28,233	3,012	-	7,318	-	821	-	-	-	8,139	*12,619	4,165	-	16,784	-	-	-	298	298	OHIO
OKLAHOMA	6,435	-50	6,385	948	-	1,422	-	695	-	-	-	2,117	*2,609	711	-	3,320	-	-	-	-	-	OKLAHOMA
OREGON	3,346	-5	3,341	410	-	1,846	-	68	526	2	528	2,442	*462	-	-	462	-	-	-	27	27	OREGON
PENNSYLVANIA	38,891	-66	38,825	1,944	-	29,699	33	2,157	2,843	-	2,843	34,732	2,070	-	-	2,070	-	-	-	79	79	PENNSYLVANIA
RHODE ISLAND 16/	3,218	-	3,218	256	-	1,034	6	99	105	-	105	1,244	24	-	-	24	1,694	-	-	-	1,694	RHODE ISLAND 16/
SOUTH CAROLINA	2,104	-	2,104	148	-	1,113	-	559	105	95	280	1,952	1	3	-	4	-	-	-	-	-	SOUTH CAROLINA
SOUTH DAKOTA	1,794	-24	1,770	76	-	342	2	4	-	-	-	348	1,331	-	-	1,331	15	-	-	-	15	SOUTH DAKOTA
TENNESSEE	5,330	232	5,562	649	-	4,185	11	240	-	-	-	4,436	-	-	-	-	477	-	-	-	477	TENNESSEE
TEXAS	22,422	-	22,422	1,852	-	7,960	-	192	-	-	-	8,152	*12,418	-	-	12,418	-	-	-	-	-	TEXAS
UTAH	1,227	-106	1,121	157	9	-	-	-	118	-	118	118	462	338	-	800	37	-	-	-	37	UTAH
VERMONT	2,625	-14	2,611	72	-	925	4	112	329	-	329	1,370	361	-	795	1,156	-	-	-	13	13	VERMONT
VIRGINIA	7,159	-210	6,949	506	-	6,137	-	205	79	-	79	6,421	-	47	-	47	-	-	-	-	-	VIRGINIA
WASHINGTON	3,728	-16	3,712	476	15	2,696	43	473	-	-	-	3,212	9	-	-	9	-	-	-	-	-	WASHINGTON
WEST VIRGINIA	6,529	-	6,529	111	-	5/ 3,272	-	44	3,102	-	3,102	6,418	(5/)	-	-	-	-	-	-	-	-	WEST VIRGINIA
WISCONSIN 17/	13,075	-	13,075	858	-	2,587	58	-	-	1,438	1,438	4,083	3,517	559	-	4,076	4,058	-	-	-	4,058	WISCONSIN 17/
WYOMING	603	-12	591	16	-	510	-	13	52	-	52	575	-	-	-	-	-	-	-	-	-	WYOMING
DISTRICT OF COLUMBIA	1,751	-	1,751	197	-	-	-	-	-	-	-	-	-	1,554	-	1,554	-	-	-	-	-	DISTRICT OF COLUMBIA
TOTAL	439,178	-2,073	437,105	35,423	521	160,532	997	18,576	44,904	9,687	54,591	234,696	101,492	14,692	1,911	118,115	37,997	1,988	7,291	1,074	48,350	TOTAL

1/ AMOUNTS DISTRIBUTED DURING THE CALENDAR YEAR OFTEN DIFFER FROM ACTUAL COLLECTIONS BECAUSE OF UNDISTRIBUTED FUNDS AND LAG BETWEEN ACCOUNTS OF COLLECTING AND EXPENDING AGENCIES.

2/ IN MANY STATES THE PROCEEDS OF HIGHWAY-USER TAXES ARE PLACED IN A COMMON FUND FROM WHICH A DISTRIBUTION IS MADE. THE AMOUNTS SO DISTRIBUTED HAVE BEEN PRORATED IN PROPORTION TO THE RECEIPTS NOT OTHERWISE DEDICATED. SEE TABLES G-3 AND MC-2.

3/ COLLECTION EXPENSES IN MANY STATES INCLUDE SERVICE CHARGES DEDUCTED BY COUNTY AND LOCAL COLLECTORS. SEE TABLE SF-9 FOR DETAILS OF AMOUNTS INCLUDED IN THIS COLUMN.

4/ WHERE REPORTED SEPARATELY FROM COLLECTION EXPENSES, MISCELLANEOUS EXPENSES OF MOTOR-VEHICLE, MOTOR-FUEL, AND MOTOR-CARRIER REGULATION ARE SHOWN IN THIS COLUMN.

5/ THE FOLLOWING AMOUNTS FOR CONSTRUCTION AND MAINTENANCE OF COUNTY ROADS UNDER STATE CONTROL ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES: DELAWARE, $203,000; NORTH CAROLINA, $2,312,000; WEST VIRGINIA, $920,000.

6/ AMOUNTS DISTRIBUTED FOR STATE PARK AND FOREST ROADS, ETC. WERE REPORTED SEPARATELY, RATHER THAN UNDER "STATE HIGHWAY PURPOSES", ON TABLE MV-3 FOR 1939 AND PRIOR YEARS.

7/ REIMBURSEMENT TO COUNTIES AND LOCAL UNITS OF GOVERNMENT FOR AMOUNTS SPENT ON ROADS NOW ON STATE SYSTEM.

8/ IN STATES INDICATED BY STAR (*) LAW PROVIDES THAT THESE FUNDS MAY ALSO BE USED FOR SERVICE OF LOCAL HIGHWAY OBLIGATIONS. AMOUNTS SO USED NOT REPORTED SEPARATELY. IN COLORADO FUNDS MAY BE USED ON BOTH STATE AND LOCAL ROADS.

9/ THIS COLUMN SHOWS SPECIFIC ALLOTMENTS FOR CITY STREETS. WHERE REPORTED SEPARATELY, FUNDS ALLOTTED FOR URBAN EXTENSIONS OF STATE HIGHWAY SYSTEM ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES.

10/ TO STATE GENERAL FUNDS EXCEPT IN THE FOLLOWING STATES: ALABAMA, COUNTY AND MUNICIPAL GENERAL FUNDS; CALIFORNIA, GENERAL FUNDS OF COUNTIES AND CITIES, $8,784,000; NEW MEXICO, COUNTY GENERAL FUNDS, $385,000; WISCONSIN, $1,381,000 TO TOWNS, CITIES, AND VILLAGES IN LIEU OF PERSONAL PROPERTY TAX FORMERLY IMPOSED ON MOTOR VEHICLES. ALLOCATIONS TO COUNTY OR LOCAL GENERAL FUNDS MAY HAVE BEEN USED IN PART FOR HIGHWAYS, BUT SUCH AMOUNTS NOT REPORTED.

11/ FOR THE FOLLOWING PURPOSES: DELAWARE, STATE PARKS AND LANDS, MOSQUITO CONTROL, CCC DITCHING; NEW JERSEY, DEBT SERVICE ON INSTITUTIONAL CONSTRUCTION BONDS, $260,000, BOARD OF COMMERCE AND NAVIGATION, $389,000; OHIO, CARE OF INDIGENT PERSONS INJURED IN MOTOR-VEHICLE ACCIDENTS; OREGON, STATE PARKS; PENNSYLVANIA, AVIATION, $71,000, COOPERATIVE WORK OTHER DEPARTMENTS, $5,000; VERMONT, DEBT SERVICE ON NONHIGHWAY PORTION OF FLOOD RELIEF BONDS.

12/ TO METROPOLITAN DISTRICT COMMISSION FOR PARKWAYS AND BOULEVARDS.

13/ INCLUDES DEBT SERVICE CHARGES ON EMERGENCY RELIEF BOND ISSUES, PRORATED IN PROPORTION TO USE OF PROCEEDS FOR STATE HIGHWAYS, LOCAL ROADS AND STREETS, AND NONHIGHWAY PURPOSES.

14/ DEBT SERVICE ON HIGHWAY RELIEF BONDS, A STATE OBLIGATION INCURRED FOR IMPROVEMENT OF LOCAL ROADS.

15/ APPROPRIATIONS FOR HIGHWAY PURPOSES OUT OF STATE GENERAL FUND HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

16/ EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE STATE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

17/ MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES ARE PAID INTO HIGHWAY ACCOUNT OF STATE GENERAL FUND, AND ARE USED FOR ANY PURPOSE, INCLUDING HIGHWAYS. EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST RECEIPTS FROM MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES, PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS.

DISPOSITION OF STATE MOTOR-CARRIER TAX RECEIPTS - 1940

COMPILED FOR CALENDAR YEAR FROM REPORTS OF STATE AUTHORITIES

STATE	NET TOTAL RECEIPTS OF CALENDAR YEAR	ADJUSTMENTS DUE TO UNDISTRIBUTED FUNDS, ETC. 1/	NET TOTAL FUNDS DISTRIBUTED 2/	EXPENSES OF COLLECTION AND ADMINISTRATION	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE HIGHWAYS 3/	ON STATE PARK AND FOREST ROADS, ETC. 4/	STATE HIGHWAY POLICE	SERVICE OF STATE HIGHWAY OBLIGATIONS: STATE HIGHWAY BONDS AND NOTES	REIMBURSEMENT OBLIGATIONS 5/	TOTAL	TOTAL FOR STATE HIGHWAY PURPOSES 4/	FOR LOCAL ROADS AND STREETS: FOR WORK ON COUNTY AND LOCAL ROADS 3/ 6/	FOR WORK ON CITY STREETS 7/	SERVICE OF LOCAL HIGHWAY OBLIGATIONS	TOTAL	FOR NONHIGHWAY PURPOSES: TO STATE GENERAL FUNDS	FOR EDUCATION	FOR STATE PARKS	TOTAL	STATE
	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	
ALABAMA	328	19	347	56	281	1	-	-	-	-	282	9	-	-	9	-	-	-	-	ALABAMA
ARIZONA	185	16	201	39	155	-	6	-	-	-	161	1	-	-	1	-	-	-	-	ARIZONA
ARKANSAS	3	-	3	2	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	ARKANSAS
CALIFORNIA	3,155	-241	2,914	463	101	-	-	-	-	-	101	4	-	-	4	2,346	-	-	2,346	CALIFORNIA
COLORADO	784	-61	723	119	204	-	12	78	-	78	294	310	-	-	310	-	-	-	-	COLORADO
CONNECTICUT	320	8	328	71	119	-	-	-	21	21	140	-	117	-	117	-	-	-	-	CONNECTICUT
DELAWARE	(8/)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	DELAWARE
FLORIDA	361	-	361	75	-	-	-	-	-	-	-	-	11	270	281	-	5	-	5	FLORIDA
GEORGIA	96	-9	87	68	19	-	-	-	-	-	19	-	-	-	-	-	-	-	-	GEORGIA
IDAHO	64	7	71	20	20	-	31	-	-	-	51	-	-	-	-	-	-	-	-	IDAHO
ILLINOIS	(8/)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ILLINOIS
INDIANA	1,472	-78	1,394	107	706	-	35	-	-	-	741	425	76	-	501	45	-	-	45	INDIANA
IOWA	412	-32	380	90	48	-	-	-	37	37	85	*205	-	-	205	-	-	-	-	IOWA
KANSAS	1,417	-	1,417	348	709	-	14	23	70	93	816	253	-	-	253	-	-	-	-	KANSAS
KENTUCKY	357	11	368	54	272	-	5	-	-	-	277	37	-	-	37	-	-	-	-	KENTUCKY
LOUISIANA	113	-	113	22	-	-	-	-	-	-	-	-	-	-	-	91	-	-	91	LOUISIANA
MAINE	19	-	19	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MAINE
MARYLAND	(9/)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MARYLAND
MASSACHUSETTS	152	-	152	46	-	-	-	-	-	-	-	-	-	-	-	106	-	-	106	MASSACHUSETTS
MICHIGAN	501	700	1,201	335	866	-	-	-	-	-	866	-	-	-	-	-	-	-	-	MICHIGAN
MINNESOTA	43	-	43	42	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	MINNESOTA
MISSISSIPPI	165	-	165	46	-	-	-	-	-	-	-	*119	-	-	119	-	-	-	-	MISSISSIPPI
MISSOURI	866	-772	94	94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MISSOURI
MONTANA	60	4	64	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MONTANA
NEBRASKA	37	-	37	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NEBRASKA
NEVADA	264	-4	260	11	216	-	33	-	-	-	249	-	-	-	-	-	-	-	-	NEVADA
NEW HAMPSHIRE	3	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NEW HAMPSHIRE
NEW JERSEY	100	1	101	-	101	-	-	-	-	-	101	-	-	-	-	-	-	-	-	NEW JERSEY
NEW MEXICO	224	65	289	55	234	-	-	-	-	-	234	-	-	-	-	-	-	-	-	NEW MEXICO
NEW YORK	36	-	36	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NEW YORK
NORTH CAROLINA	397	-	397	15	3/ 283	-	-	96	3	99	382	(3/)	-	-	-	-	-	-	-	NORTH CAROLINA
NORTH DAKOTA	42	-	42	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NORTH DAKOTA
OHIO	598	24	622	102	387	-	-	-	-	-	387	133	-	-	133	-	-	-	-	OHIO
OKLAHOMA	204	47	251	25	139	-	-	-	-	-	139	87	-	-	87	-	-	-	-	OKLAHOMA
OREGON	1,357	3	1,360	213	708	-	49	202	1	203	960	*177	-	-	177	-	-	10	10	OREGON
PENNSYLVANIA	5	-	5	-	5	-	-	-	-	-	5	-	-	-	-	-	-	-	-	PENNSYLVANIA
RHODE ISLAND	9	-	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RHODE ISLAND
SOUTH CAROLINA	268	-15	253	73	156	-	-	-	-	-	156	-	24	-	24	-	-	-	-	SOUTH CAROLINA
SOUTH DAKOTA	433	26	459	29	405	3	4	-	-	-	412	-	-	-	-	18	-	-	18	SOUTH DAKOTA
TENNESSEE	51	-	51	27	-	-	-	-	-	-	-	-	-	-	-	24	-	-	24	TENNESSEE
TEXAS	123	-	123	115	8	-	-	-	-	-	8	-	-	-	-	-	-	-	-	TEXAS
UTAH 10/	-	81	81	9	72	-	-	-	-	-	72	-	-	-	-	-	-	-	-	UTAH 10/
VERMONT	(8/)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	VERMONT
VIRGINIA	363	-1	362	54	293	-	9	4	-	4	306	-	2	-	2	-	-	-	-	VIRGINIA
WASHINGTON	174	-	174	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	WASHINGTON
WEST VIRGINIA	120	-	120	-	53	-	-	67	-	67	120	-	-	-	-	-	-	-	-	WEST VIRGINIA
WISCONSIN	1,692	-	1,692	90	-	-	-	-	-	-	-	-	-	-	-	1,602	-	-	1,602	WISCONSIN
WYOMING	292	6	298	27	265	-	6	-	-	-	271	-	-	-	-	-	-	-	-	WYOMING
DISTRICT OF COLUMBIA	248	-	248	-	-	-	-	-	-	-	-	-	-	-	-	248	-	-	248	DISTRICT OF COLUMBIA
TOTAL	17,913	-195	17,718	3,326	6,827	4	204	470	132	602	7,637	1,760	230	270	2,260	4,480	5	10	4,495	TOTAL

1/ AMOUNTS DISTRIBUTED DURING THE CALENDAR YEAR OFTEN DIFFER FROM ACTUAL COLLECTIONS BECAUSE OF UNDISTRIBUTED FUNDS AND LAG BETWEEN ACCOUNTS OF COLLECTING AND EXPENDING AGENCIES.

2/ IN MANY STATES THE PROCEEDS OF HIGHWAY-USER TAXES ARE PLACED IN A COMMON FUND FROM WHICH A DISTRIBUTION IS MADE. THE AMOUNTS SO DISTRIBUTED HAVE BEEN PRORATED IN PROPORTION TO THE RECEIPTS NOT OTHERWISE DEDICATED. SEE TABLES G-3 AND MV-3.

3/ APPROXIMATELY $118,000 FOR USE ON COUNTY ROADS UNDER STATE CONTROL IN NORTH CAROLINA INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES.

4/ AMOUNTS DISTRIBUTED FOR STATE PARK AND FOREST ROADS, ETC. WERE REPORTED SEPARATELY, RATHER THAN UNDER "STATE HIGHWAY PURPOSES", ON TABLE MC-2 FOR 1939 AND PRIOR YEARS.

5/ REIMBURSEMENT TO COUNTIES AND LOCAL UNITS OF GOVERNMENT FOR AMOUNTS SPENT ON ROADS NOW ON STATE SYSTEM.

6/ IN STATES INDICATED BY STAR (*) LAW PROVIDES THAT THESE FUNDS MAY ALSO BE USED FOR SERVICE OF LOCAL HIGHWAY OBLIGATIONS. AMOUNTS SO USED NOT REPORTED SEPARATELY. IN COLORADO FUNDS MAY BE USED ON BOTH STATE AND LOCAL ROADS.

7/ THIS COLUMN SHOWS SPECIFIC ALLOTMENTS FOR CITY STREETS. WHERE REPORTED SEPARATELY, FUNDS ALLOTTED FOR URBAN EXTENSIONS OF STATE HIGHWAY SYSTEM ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES.

8/ NO SPECIAL TAXES ON MOTOR CARRIERS REPORTED.

9/ TON-MILE AND PASSENGER-MILE TAXES PAID BY MOTOR CARRIERS IN LIEU OF REGISTRATION FEES INCLUDED IN MOTOR-VEHICLE RECEIPTS, TABLE MV-3.

10/ MOTOR-CARRIER TAXES NO LONGER IMPOSED. AMOUNTS SHOWN REPRESENT DISTRIBUTION OF REVENUES COLLECTED IN PRIOR YEARS.

DISPOSITION OF RECEIPTS FROM STATE IMPOSTS ON HIGHWAY USERS-1940

COMPILED FOR CALENDAR YEAR FROM REPORTS OF STATE AUTHORITIES

STATE	NET TOTAL RECEIPTS OF CALENDAR YEAR 1/	ADJUSTMENTS DUE TO UNDISTRIBUTED FUNDS, ETC. 2/	NET TOTAL FUNDS DISTRIBUTED	EXPENSES OF COLLECTION AND ADMINISTRATION 3/	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE HIGHWAYS 4/	FOR STATE HIGHWAY PURPOSES: CONSTRUCTION, MAINTENANCE, AND ADMINISTRATION: ON STATE PARK AND FOREST ROADS, ETC. 5/	FOR STATE HIGHWAY PURPOSES: STATE HIGHWAY POLICE	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: STATE HIGHWAY BONDS AND NOTES	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: REIMBURSEMENT OBLIGATIONS 6/	FOR STATE HIGHWAY PURPOSES: SERVICE OF STATE HIGHWAY OBLIGATIONS: TOTAL	TOTAL FOR STATE HIGHWAY PURPOSES 5/	FOR LOCAL ROADS AND STREETS: FOR WORK ON COUNTY AND LOCAL ROADS 4/ 7/	FOR LOCAL ROADS AND STREETS: FOR WORK ON CITY STREETS 8/	FOR LOCAL ROADS AND STREETS: SERVICE OF LOCAL HIGHWAY OBLIGATIONS	FOR LOCAL ROADS AND STREETS: TOTAL	FOR NONHIGHWAY PURPOSES: TO GENERAL FUNDS 9/: MOTOR-FUEL INSPECTION FEES, DEALERS LICENSES, ETC.	FOR NONHIGHWAY PURPOSES: TO GENERAL FUNDS 9/: ALL OTHER HIGHWAY-USER IMPOSTS	FOR NONHIGHWAY PURPOSES: FOR RELIEF OF UNEMPLOYMENT OR DESTITUTION	FOR NONHIGHWAY PURPOSES: FOR EDUCATION	FOR NONHIGHWAY PURPOSES: FOR OTHER PURPOSES 10/	FOR NONHIGHWAY PURPOSES: TOTAL	STATE
	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	1,000 DOLLARS	
ALABAMA	20,411	256	20,667	571	8,157	16	270	2,627	-	2,627	11,070	7,845	347	-	8,192	-	834	-	-	-	834	ALABAMA
ARIZONA	6,179	28	6,207	369	4,203	-	164	-	-	-	4,367	•1,471	-	-	1,471	-	-	-	-	-	-	ARIZONA
ARKANSAS	14,814	386	15,200	444	3,493	-	191	7,174	2,471	9,645	13,329	1,222	-	205	1,427	-	-	-	-	-	-	ARKANSAS
CALIFORNIA	83,047	-1,656	81,391	4,137	34,215	-	2,950	3,695	-	3,695	40,860	•18,092	4,313	-	22,405	-	11,164	2,825	-	-	13,989	CALIFORNIA
COLORADO	11,872	-96	11,776	828	5,105	-	315	1,967	-	1,967	7,397	3,561	-	-	3,561	-	-	-	-	-	-	COLORADO
CONNECTICUT	18,789	-533	18,256	1,012	11,239	-	791	-	1,937	1,937	14,017	3,109	117	-	3,226	-	1	-	-	-	1	CONNECTICUT
DELAWARE	3,577	-	3,577	157	4/ 2,465	-	272	211	444	655	3,392	(4/)	2	-	2	-	-	-	-	26	26	DELAWARE
FLORIDA	35,811	87	35,898	1,141	13,800	-	321	-	9,357	9,357	23,478	-	11	270	281	375	1,924	-	8,682	17	10,998	FLORIDA
GEORGIA	25,705	64	25,769	1,160	14,602	-	771	83	-	83	15,456	5,337	-	-	5,337	29	-	-	3,781	6	3,816	GEORGIA
IDAHO	6,282	55	6,337	105	3,605	-	137	101	-	101	3,843	•2,389	-	-	2,389	-	-	-	-	-	-	IDAHO
ILLINOIS	66,584	-103	66,481	2,159	22,270	-	1,688	9,840	-	9,840	33,798	11,607	10,337	1,595	23,539	153	203	4,462	2,167	-	6,985	ILLINOIS
INDIANA	38,136	-487	37,649	1,367	19,643	-	980	-	-	-	20,623	11,834	2,110	-	13,944	465	1,250	-	-	-	1,715	INDIANA
IOWA	28,054	5	28,059	815	10,534	-	402	-	8,302	8,302	19,238	•7,985	21	-	8,006	-	-	-	-	-	-	IOWA
KANSAS	15,991	765	16,756	1,356	10,211	-	219	335	1,000	1,335	11,765	3,635	-	-	3,635	-	-	-	-	-	-	KANSAS
KENTUCKY	20,583	-555	20,028	632	14,687	-	266	-	-	-	14,953	2,606	-	-	2,606	-	1,837	-	-	-	1,837	KENTUCKY
LOUISIANA	24,176	-1,642	22,534	277	8,295	-	500	7,214	-	7,214	16,009	-	-	-	-	-	2,551	1,305	1,196	1,196	6,248	LOUISIANA
MAINE	10,110	235	10,345	300	5,658	-	317	2,770	-	2,770	8,745	1,158	-	-	1,158	-	142	-	-	-	142	MAINE
MARYLAND	18,146	-	18,146	433	9,128	-	442	783	-	783	10,353	881	4,523	621	6,025	-	1,335	-	-	-	1,335	MARYLAND
MASSACHUSETTS	28,925	-319	28,606	1,760	5,762	11/ 1,093	502	12/ 3,823	-	3,823	11,180	12,134	-	12/ 2,269	14,403	27	106	12/ 1,130	-	-	1,263	MASSACHUSETTS
MICHIGAN	57,014	1,081	58,095	2,529	22,767	-	651	4,081	-	4,081	27,499	•28,067	-	-	28,067	-	-	-	-	-	-	MICHIGAN
MINNESOTA	28,874	-251	28,623	780	16,750	-	467	2,667	1,606	4,273	21,490	•6,106	-	-	6,106	102	145	-	-	-	247	MINNESOTA
MISSISSIPPI	15,105	90	15,195	406	2,979	13/ 429	242	3,523	-	3,523	7,173	•7,616	-	-	7,616	-	-	-	-	-	-	MISSISSIPPI
MISSOURI	25,071	-778	24,293	766	13,854	-	716	8,682	187	8,869	23,439	-	-	-	-	88	-	-	-	-	88	MISSOURI
MONTANA	6,855	233	7,088	155	4,253	-	243	947	-	947	5,448	1,441	44	-	1,485	-	-	-	-	-	-	MONTANA
NEBRASKA	14,704	-45	14,659	432	6,255	-	157	-	-	-	6,412	•5,115	378	-	5,493	-	-	2,322	-	-	2,322	NEBRASKA
NEVADA	2,084	-14	2,070	69	1,855	-	58	81	7	88	2,001	-	-	-	-	-	-	-	-	-	-	NEVADA
NEW HAMPSHIRE	6,672	-	6,672	158	4,738	-	193	804	-	804	5,735	435	-	14/ 344	779	-	-	-	-	-	-	NEW HAMPSHIRE
NEW JERSEY	46,999	335	47,334	2,462	18,001	537	597	3,951	-	3,951	23,086	8,295	-	2,001	10,296	-	15/ 5,519	3,551	1,095	1,325	11,490	NEW JERSEY
NEW MEXICO	6,917	66	6,983	473	3,589	-	141	1,897	-	1,897	5,627	231	36	-	267	-	616	-	-	-	616	NEW MEXICO
NEW YORK 16/	129,096	-1,947	127,149	3,305	18,593	506	1,427	11,819	-	11,819	32,345	•20,394	7,123	-	27,517	-	63,982	-	-	-	63,982	NEW YORK 16/
NORTH CAROLINA	35,943	382	36,325	696	4/ 25,161	-	547	8,490	298	8,788	34,496	(4/)	-	-	-	984	-	-	-	149	1,133	NORTH CAROLINA
NORTH DAKOTA	5,155	58	5,213	257	3,400	-	14	-	-	-	3,414	1,539	-	-	1,539	-	3	-	-	-	3	NORTH DAKOTA
OHIO	81,763	-966	80,797	3,278	29,624	-	821	-	-	-	30,445	•22,412	11,373	-	33,785	-	12,991	-	-	298	13,289	OHIO
OKLAHOMA	21,706	28	21,734	1,483	11,910	-	695	-	-	-	12,605	•5,965	1,449	-	7,414	232	-	-	-	-	232	OKLAHOMA
OREGON	16,048	-2	16,046	666	9,672	-	376	2,759	11	2,770	12,818	•2,423	-	-	2,423	-	-	-	-	139	139	OREGON
PENNSYLVANIA	101,391	-66	101,325	2,141	61,004	148	4,431	5,758	-	5,758	71,341	•12,019	-	-	12,019	-	15,662	-	-	162	15,824	PENNSYLVANIA
RHODE ISLAND 17/	7,172	-	7,172	279	2,406	13	231	245	-	245	2,895	56	-	-	56	-	3,942	-	-	-	3,942	RHODE ISLAND 17/
SOUTH CAROLINA	16,209	-15	16,194	292	13,059	-	559	1,906	844	2,750	13,368	•2,268	49	-	2,317	217	-	-	-	-	217	SOUTH CAROLINA
SOUTH DAKOTA	6,738	-104	6,634	148	4,434	25	51	2	-	2	4,512	1,867	-	-	1,867	74	33	-	-	-	107	SOUTH DAKOTA
TENNESSEE	27,559	-129	27,430	1,040	8,726	34	240	2,848	680	3,528	12,528	5,930	-	-	5,930	1,208	501	-	-	6,223	7,932	TENNESSEE
TEXAS	70,075	-390	69,685	2,709	29,835	-	719	-	7,287	7,287	37,841	•17,549	-	-	17,549	-	-	-	11,586	-	11,586	TEXAS
UTAH	5,215	-17	5,198	204	3,814	-	152	118	-	118	4,084	565	308	-	873	-	37	-	-	-	37	UTAH
VERMONT	5,406	-14	5,392	74	1,985	8	112	705	-	705	2,810	1,848	-	632	2,480	-	-	-	-	28	28	VERMONT
VIRGINIA	26,916	-151	26,765	590	4/ 24,988	-	519	221	-	221	25,728	4/ 320	118	-	438	-	-	-	-	9	9	VIRGINIA
WASHINGTON	21,087	-16	21,071	714	9,668	40	476	12/ 127	50	177	10,361	•6,378	2,373	12/ 173	8,924	-	-	12/ 1,072	-	-	1,072	WASHINGTON
WEST VIRGINIA	17,340	-	17,340	126	4/ 9,231	-	44	7,939	-	7,939	17,214	(4/)	-	-	-	-	-	-	-	-	-	WEST VIRGINIA
WISCONSIN 18/	36,078	-	36,078	1,185	6,992	158	-	-	3,887	3,887	11,037	9,506	1,510	-	11,016	-	12,840	-	-	-	12,840	WISCONSIN 18/
WYOMING	3,615	-6	3,609	56	2,680	-	67	117	-	117	2,864	689	-	-	689	-	-	-	-	-	-	WYOMING
DISTRICT OF COLUMBIA	5,228	3	5,231	197	-	-	-	-	-	-	-	-	4,779	-	4,779	7	248	-	-	-	255	DISTRICT OF COLUMBIA
TOTAL	1,327,227	-6,145	1,321,082	46,693	576,295	3,007	26,449	110,310	38,418	148,728	754,479	263,900	51,321	8,110	323,331	3,961	137,866	16,667	28,507	9,578	196,579	TOTAL

1/ INCLUDES RECEIPTS FROM MOTOR-FUEL TAXES, MOTOR-VEHICLE FEES AND FINES, AND SPECIAL IMPOSTS ON MOTOR VEHICLES OPERATED FOR HIRE (MOTOR-CARRIER TAXES). SEE TABLES G-3, MV-3, AND MC-2, WHICH GIVE DISTRIBUTION OF RECEIPTS SEPARATELY.

2/ AMOUNTS DISTRIBUTED DURING THE CALENDAR YEAR OFTEN DIFFER FROM ACTUAL COLLECTIONS BECAUSE OF UNDISTRIBUTED FUNDS AND LAG BETWEEN ACCOUNTS OF COLLECTING AND EXPENDING AGENCIES.

3/ INCLUDES EXPENSES OF COLLECTION AND ADMINISTRATION OF MOTOR-FUEL TAX, MOTOR-VEHICLE FEES, AND MOTOR-CARRIER TAXES, AND MISCELLANEOUS EXPENSES OF MOTOR-VEHICLE REGULATION.

4/ THE FOLLOWING AMOUNTS FOR CONSTRUCTION AND MAINTENANCE OF COUNTY ROADS UNDER STATE CONTROL ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES: DELAWARE, $629,000; NORTH CAROLINA, $10,519,000; VIRGINIA, $7,759,000; WEST VIRGINIA, $2,955,000. THE 3 COUNTIES IN VIRGINIA WHICH HAVE COUNTY ROADS NOT UNDER STATE CONTROL RECEIVED $320,000.

5/ AMOUNTS DISTRIBUTED FOR STATE PARK AND FOREST ROADS, ETC. WERE REPORTED SEPARATELY, RATHER THAN UNDER "STATE HIGHWAY PURPOSES", ON TABLE DF FOR 1939 AND PRIOR YEARS.

6/ REIMBURSEMENT TO COUNTIES AND LOCAL UNITS OF GOVERNMENT FOR AMOUNTS SPENT ON ROADS NOW ON STATE SYSTEM.

7/ IN STATES INDICATED BY STAR (•) LAW PROVIDES THAT THESE FUNDS MAY ALSO BE USED FOR SERVICE OF LOCAL HIGHWAY OBLIGATIONS. AMOUNTS SO USED NOT REPORTED SEPARATELY. IN COLORADO FUNDS MAY BE USED ON BOTH STATE AND LOCAL ROADS.

8/ THIS COLUMN SHOWS SPECIFIC ALLOTMENTS FOR CITY STREETS. WHERE REPORTED SEPARATELY, FUNDS ALLOTTED FOR URBAN EXTENSIONS OF STATE HIGHWAY SYSTEM ARE INCLUDED IN ALLOTMENTS FOR STATE HIGHWAY PURPOSES.

9/ TO STATE GENERAL FUNDS EXCEPT AS FOLLOWS: ALABAMA AND CALIFORNIA, COUNTY AND MUNICIPAL GENERAL FUNDS; LOUISIANA, PARISH GENERAL FUNDS; NEW MEXICO, COUNTY GENERAL FUNDS; WISCONSIN, $3,731,000 TO TOWNS, CITIES, AND VILLAGES IN LIEU OF PERSONAL PROPERTY TAX FORMERLY IMPOSED ON MOTOR VEHICLES. ALLOCATIONS TO COUNTY OR LOCAL GENERAL FUNDS MAY HAVE BEEN USED IN PART FOR HIGHWAYS, BUT SUCH AMOUNTS NOT REPORTED.

10/ FOR THE FOLLOWING PURPOSES: DELAWARE, STATE PARKS AND LANDS, $5,000, MOSQUITO CONTROL, $16,000, CCC DITCHING, $5,000; FLORIDA, AVIATION; GEORGIA, INVESTIGATION OF WATER RESOURCES; LOUISIANA, HARBOR IMPROVEMENT; NEW JERSEY, DEBT SERVICE ON INSTITUTIONAL CONSTRUCTION BONDS, $531,000, BOARD OF COMMERCE AND NAVIGATION, $794,000; NORTH CAROLINA, STATE PROBATION AND PAROLE COMMISSIONS; OHIO, CARE OF INDIGENT PERSONS INJURED IN MOTOR-VEHICLE ACCIDENTS; OREGON, STATE PARKS; PENNSYLVANIA, AVIATION, $146,000, COOPERATIVE WORK OTHER DEPARTMENTS, $16,000; TENNESSEE, DEBT SERVICE ON NONHIGHWAY BONDS; VERMONT, DEBT SERVICE ON NONHIGHWAY PORTION OF FLOOD RELIEF BONDS; VIRGINIA, AVIATION.

11/ TO METROPOLITAN DISTRICT COMMISSION FOR PARKWAYS AND BOULEVARDS.

12/ INCLUDES DEBT SERVICE CHARGES ON EMERGENCY RELIEF BOND ISSUES, PRORATED IN PROPORTION TO USE OF PROCEEDS FOR STATE HIGHWAYS, LOCAL ROADS AND STREETS, AND NONHIGHWAY PURPOSES.

13/ TO GULF COAST COUNTIES FOR MAINTENANCE OF SEA WALL PROTECTING STATE HIGHWAYS.

14/ INCLUDES $240,000 PAID ON HIGHWAY RELIEF BONDS ISSUED BY STATE FOR LOCAL ROADS, AND $104,000 ON PRO-RATA SHARE OF HIGHWAY FLOOD BONDS.

15/ INCLUDES $3,000,000 ORIGINALLY APPROPRIATED FOR RELIEF, BUT LATER TRANSFERRED BY LEGISLATIVE ACTION TO STATE GENERAL FUND.

16/ APPROPRIATIONS FOR HIGHWAY PURPOSES OUT OF STATE GENERAL FUND HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

17/ EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST PAYMENTS OF MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES TO THE STATE GENERAL FUND AND PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS NOT OTHERWISE DEDICATED.

18/ MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES ARE PAID INTO HIGHWAY ACCOUNT OF STATE GENERAL FUND, AND ARE USED FOR ANY PURPOSE, INCLUDING HIGHWAYS. EXPENDITURES FOR HIGHWAY PURPOSES HAVE BEEN CREDITED AGAINST RECEIPTS FROM MOTOR-FUEL TAX AND MOTOR-VEHICLE REVENUES, PRORATED IN PROPORTION TO NET RECEIPTS FROM THESE IMPOSTS.

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

AS OF SEPTEMBER 30, 1941

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 1,478,160	$ 734,140	58.2	$ 6,712,877	$ 3,332,605	219.4	$ 2,155,404	$ 1,072,000	57.7	$ 937,670
Arizona	528,890	380,976	33.1	1,520,054	1,039,490	54.7	692,577	437,998	17.6	993,258
Arkansas	2,306,936	1,057,900	33.0	1,189,406	593,887	45.0	643,482	320,692	38.4	379,609
California	2,985,331	1,602,150	67.8	6,831,858	3,695,654	76.7	2,442,327	1,319,196	47.0	2,293,984
Colorado	1,830,304	1,036,002	102.9	2,128,406	1,234,463	143.0	946,905	534,573	63.1	1,792,048
Connecticut	711,753	347,250	7.2	1,782,108	872,444	22.6	1,018,039	476,221	11.9	543,129
Delaware	161,292	78,259	2.7	832,264	410,217	22.4	299,647	149,824	9.5	964,421
Florida	726,447	363,224	52.4	790,609	422,194	12.9	1,992,059	971,708	22.0	2,574,738
Georgia	1,734,840	867,420	60.1	6,307,204	3,163,852	260.0	4,281,611	2,140,806	176.1	4,975,471
Idaho	769,197	474,099	46.5	1,452,670	896,825	79.5	744,770	352,533	25.1	1,145,568
Illinois	2,423,110	1,205,611	54.8	8,452,162	4,226,081	151.5	1,313,272	655,854	6.8	3,275,611
Indiana	2,286,454	1,143,037	33.4	7,179,179	3,345,574	113.3	1,048,828	524,414	16.3	1,187,880
Iowa	1,687,741	794,040	79.5	5,399,070	2,548,758	180.9	1,552,201	397,300	48.3	17,571
Kansas	2,722,963	1,380,649	125.9	4,517,261	2,271,489	283.4	3,740,394	1,629,695	142.7	3,034,643
Kentucky	1,649,115	828,370	60.2	7,268,067	3,472,718	182.1	3,334,853	1,665,199	26.6	63,131
Louisiana	780,863	390,410	21.5	2,049,901	1,016,533	40.5	2,568,556	1,259,086	56.3	3,048,042
Maine	586,610	295,745	17.4	1,932,733	992,327	23.9	316,350	158,175	5.1	376,932
Maryland	1,457,200	728,000	17.6	3,616,162	1,697,678	21.0	1,145,000	242,500	5.9	947,667
Massachusetts	1,841,207	925,139	15.6	2,728,357	1,393,614	16.6	1,175,721	584,274	8.4	2,587,729
Michigan	4,398,630	2,195,188	80.8	5,792,910	2,886,105	124.7	1,913,900	956,950	17.8	808,467
Minnesota	2,773,801	1,384,189	255.6	10,079,397	4,998,450	451.3	1,044,995	519,562	52.2	974,871
Mississippi	1,528,000	763,140	96.9	6,824,912	3,348,466	372.1	581,700	289,100	30.3	692,649
Missouri	3,546,023	1,752,996	122.5	9,943,674	4,581,855	199.3	3,137,820	722,764	43.1	3,322,492
Montana	1,002,360	566,147	55.7	2,797,717	1,587,047	117.6	1,817,409	1,033,378	129.0	3,047,638
Nebraska	711,460	350,995	97.8	7,050,962	3,545,518	638.7	1,000,298	500,149	59.0	2,195,446
Nevada	1,335,580	1,162,008	60.2	1,265,679	1,099,219	60.3	507,171	440,730	9.7	231,406
New Hampshire	158,132	78,009	3.4	1,149,390	553,787	13.8	186,503	87,573	2.4	772,510
New Jersey	2,348,574	1,174,287	20.5	3,562,648	1,781,244	22.2	22,270	11,135		1,754,818
New Mexico	511,382	315,352	42.1	1,401,016	882,765	80.8	405,333	226,824	35.2	1,535,912
New York	3,710,494	1,854,347	60.2	11,983,537	5,958,370	136.1	609,994	304,372	4.8	2,720,099
North Carolina	2,175,874	1,071,825	98.9	3,859,747	1,932,675	146.5	980,156	489,455	36.9	1,724,739
North Dakota	2,246,784	1,255,846	190.4	3,318,920	1,742,836	266.9	2,235,340	1,121,040	191.4	2,979,078
Ohio	3,366,050	1,680,631	23.4	15,883,577	7,697,616	134.2	3,825,680	1,572,500	25.6	2,262,748
Oklahoma	1,150,305	555,965	51.4	3,287,241	1,734,944	96.6	1,969,370	1,030,566	58.3	4,160,286
Oregon	1,113,005	673,096	37.2	4,112,297	2,204,640	80.7	576,548	275,190	29.9	379,224
Pennsylvania	2,901,181	1,445,098	39.6	14,121,292	6,959,761	114.4	1,427,965	705,232	10.8	1,960,988
Rhode Island	350,257	174,830	3.8	1,051,537	524,097	8.1	473,292	236,639	2.9	754,701
South Carolina	501,870	245,625	49.2	4,006,137	1,750,219	109.7	1,346,253	276,826	32.8	1,867,595
South Dakota	1,344,810	793,670	167.0	4,627,343	2,903,393	499.5	1,437,700	930,680	182.9	1,525,716
Tennessee	1,035,730	517,865	42.5	5,384,024	2,692,012	97.8	1,294,974	647,487	40.7	2,780,207
Texas	4,260,531	2,102,444	211.0	12,799,558	6,294,074	524.0	4,504,810	1,911,145	146.4	4,644,144
Utah	452,206	338,102	34.5	2,345,984	1,744,008	50.6	103,549	70,232	6.0	299,006
Vermont	316,447	156,509	10.7	1,645,765	819,232	37.6	56,299	28,150	1.3	81,521
Virginia	1,069,577	536,738	25.2	4,710,862	2,197,510	80.8	1,588,672	791,286	26.2	1,067,066
Washington	362,625	194,000	6.0	2,904,391	1,551,704	42.4	874,414	439,785	8.8	757,404
West Virginia	898,785	447,683	27.7	3,895,025	1,934,929	47.2	81,970	40,985	1.0	1,418,770
Wisconsin	704,085	349,450	43.5	6,357,268	3,000,608	191.7	1,522,491	621,400	59.0	2,579,700
Wyoming	592,467	380,262	76.3	1,949,404	1,220,635	150.9	211,772	136,167	17.3	614,172
District of Columbia	463,514	231,540	2.5	463,770	231,300	.2	310,618	124,600	1.7	302,734
Hawaii	140,808	70,395	1.1	701,887	518,147	9.5	41,366	21,894	.3	1,692,779
Puerto Rico	22,901	60,485	2.3	1,473,468	727,750	15.7	947,130	467,300	4.8	401,970
TOTALS	76,262,691	39,511,138	2,929.7	233,441,687	118,231,319	6,871.3	68,449,758	31,923,144	2,053.3	83,449,958

STATUS OF FEDERAL-AID SECONDARY OR FEEDER ROAD PROJECTS

AS OF SEPTEMBER 30, 1941

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 832,405	$ 414,568	35.8	$ 782,052	$ 402,090	47.1	$ 366,700	$ 177,280	10.7	$ 297,858
Arizona	67,371	48,972	4.5	161,385	119,428	4.4	32,795	23,839	5.2	354,133
Arkansas	330,055	164,276	27.4	235,449	117,623	17.4	327,209	159,376	15.1	73,497
California	416,996	258,240	10.5	1,137,882	807,048	11.7	129,976	74,930	3.6	399,588
Colorado	63,585	35,343	3.7	212,975	110,431	21.0				261,938
Connecticut	105,456	49,907	1.8	458,827	202,361	9.1				74,196
Delaware	31,959	15,264		274,043	135,122	12.3	102,873	37,618	3.9	158,438
Florida	112,906	56,453	4.4	1,037,852	524,376	7.4				239,387
Georgia	190,596	95,298	22.6	903,019	528,859	48.9	1,003,221	501,610	90.6	705,801
Idaho	163,914	97,878	12.0	188,523	116,006	17.7	40,937	7,402	1.2	200,463
Illinois	519,080	257,546	15.9	1,409,710	704,855	82.6	226,800	97,450	13.7	291,402
Indiana	46,400	23,200	1.8	1,693,305	813,496	84.7				598,434
Iowa	430,113	204,792	109.9	317,941	130,918	59.4	183,539	86,080	38.7	338,342
Kansas	311,119	158,045	35.2	1,868,366	938,845	132.6	569,422	271,611	52.7	670,515
Kentucky	413,140	97,595	15.0	1,377,687	355,843	82.0	625,342	174,174	28.0	134,713
Louisiana	372,100	134,040	5.7	192,608	96,249	14.9	289,362	138,761	21.5	446,100
Maine	14,200	7,100	.8	206,670	103,335	9.7	96,540	42,559	4.1	15,089
Maryland	54,000	27,000	2.0	666,000	332,825	19.8	82,000	41,000	.8	201,634
Massachusetts	163,235	85,298	4.1	643,150	334,642	10.1				368,581
Michigan	147,500	73,750	9.0	1,485,760	740,880	79.3	100,326	50,163	9.9	384,441
Minnesota	657,590	334,545	88.2	1,688,908	847,262	186.5	332,608	165,904	35.2	210,624
Mississippi	210,600	105,300	11.2	1,108,534	545,082	53.5	772,021	335,260	32.8	223,542
Missouri	266,660	133,330	32.1	653,548	312,933	58.2	438,162	165,537	76.6	639,129
Montana	174,810	99,203	26.4	291,234	165,561	34.6	157,905	89,784	21.2	573,487
Nebraska	89,712	44,257	13.2	648,437	329,496	59.7	59,375	29,687	19.5	374,879
Nevada	118,591	103,169	12.8	45,276	39,865	5.0	248,349	191,981	15.4	2,243
New Hampshire				338,140	167,149	8.2	52,105	3,572	.1	89,007
New Jersey	246,870	123,355	5.1	603,782	319,350	16.5	140,550	70,275	6.8	334,293
New Mexico	413,533	259,915	42.6	189,504	122,533	15.1	167,514	101,129	5.1	5,968
New York	670,674	350,944	16.5	827,760	410,971	17.4	322,386	161,193	4.9	477,623
North Carolina	68,690	34,345	7.0	622,389	341,298	47.9	260,248	108,715	21.3	254,837
North Dakota	49,569	26,558	2.4	3,434	3,434		808,050	793,860	42.7	483,046
Ohio	712,072	355,780	25.2	1,782,070	938,225	41.8	175,170	87,485	5.0	793,655
Oklahoma	246,780	130,349	9.7	127,338	67,173	11.9	856,486	452,224	64.6	735,049
Oregon	222,717	100,124	21.0	444,242	244,029	31.8	257,499	106,320	18.7	142,165
Pennsylvania	545,262	272,631	12.0	1,962,397	970,132	35.9	72,000	36,000	1.8	28,089
Rhode Island	88,194	44,040	.9	139,310	73,157	1.7	4,080	2,040		55,703
South Carolina	212,727	57,376	20.2	431,940	191,790	23.4	353,000	135,124	11.5	164,848
South Dakota	32,130	18,006	15.2	3,622	3,622		1,143,430	1,047,600	114.5	489,674
Tennessee	219,950	109,975	8.1	1,488,772	744,386	47.9	234,030	117,015	8.7	408,374
Texas	468,379	231,648	46.3	1,145,441	547,318	108.1	97,520	48,550	12.0	1,315,888
Utah	92,095	52,881	13.3	157,099	103,302	6.2	23,217	12,000	.3	196,507
Vermont	36,231	18,109	1.2				170,240	85,120	7.8	193
Virginia	339,398	155,485	11.1	374,996	171,246	9.1	77,850	30,750	4.5	349,609
Washington	130,422	70,865	16.2	460,359	219,662	10.5	92,166	20,000	4.8	196,252
West Virginia	86,300	43,150	2.4	618,024	308,399	23.8	16,500	8,250		315,490
Wisconsin	586,425	293,120	29.6	1,920,667	862,483	61.5	60,662	29,420	.8	132,143
Wyoming	364,163	157,111	18.8	297,985	111,188	25.3	201,892	109,741	9.0	
District of Columbia	52,747	26,374	.6	28,024	13,550	.3				77,117
Hawaii				2,375	2,375					249,280
Puerto Rico	45,960	22,305	2.5	185,404	90,550	8.1				134,597
TOTALS	12,235,381	6,078,815	833.9	33,844,215	16,882,753	1,722.0	11,772,057	6,428,389	845.3	15,667,821

PUBLICATIONS *of the* PUBLIC ROADS ADMINISTRATION

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Agency and as the Agency does not sell publications, please send no remittance to the Federal Works Agency.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1932. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1936. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1937. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1938. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1939. 10 cents.

Work of the Public Roads Administration, 1940.

HOUSE DOCUMENT NO. 462

Part 1 . . . Nonuniformity of State Motor-Vehicle Traffic Laws. 15 cents.

Part 2 . . . Skilled Investigation at the Scene of the Accident Needed to Develop Causes. 10 cents.

Part 3 . . . Inadequacy of State Motor-Vehicle Accident Reporting. 10 cents.

Part 4 . . . Official Inspection of Vehicles. 10 cents.

Part 5 . . . Case Histories of Fatal Highway Accidents. 10 cents.

Part 6 . . . The Accident-Prone Driver. 10 cents.

MISCELLANEOUS PUBLICATIONS

No. 76MP . . The Results of Physical Tests of Road-Building Rock. 25 cents.

No. 191MP. . Roadside Improvement. 10 cents.

No. 272MP. . Construction of Private Driveways. 10 cents.

No. 279MP. . Bibliography on Highway Lighting. 5 cents.

Highway Accidents. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

Guides to Traffic Safety. 10 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

Transition Curves for Highways. 60 cents.

Highways of History. 25 cents.

Specifications for Construction of Roads and Bridges in National Forests and National Parks. 1 dollar.

DEPARTMENT BULLETINS

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

No. 1486D . . Highway Bridge Location. 15 cents.

TECHNICAL BULLETINS

No. 55T . . . Highway Bridge Surveys. 20 cents.

No. 265T. . . Electrical Equipment on Movable Bridges. 35 cents.

Single copies of the following publications may be obtained from the Public Roads Administration upon request. They cannot be purchased from the Superintendent of Documents.

MISCELLANEOUS PUBLICATIONS

No. 296MP. . Bibliography on Highway Safety.

House Document No. 272 . . . Toll Roads and Free Roads.

Indexes to PUBLIC ROADS, volumes 6–8 and 10–20, inclusive.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

UNIFORM VEHICLE CODE

Act I.—Uniform Motor Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor Vehicle Civil Liability Act.

Act IV.—Uniform Motor Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinances.

A complete list of the publications of the Public Roads Administration, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to Public Roads Administration, Willard Bldg., Washington, D. C.

STATUS OF FEDERAL-AID GRADE CROSSING PROJECTS

AS OF SEPTEMBER 30, 1941

STATE	COMPLETED DURING CURRENT FISCAL YEAR					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Federal Aid	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Federal Aid	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	
Alabama	$ 2,839	$ 2,839			1	$ 424,722	$ 422,700	6	5	2	$ 71,235	$ 71,235	2		6	$ 810,911
Arizona						186,306	186,306	1	1		121,422	101,218		1	2	119,175
Arkansas	46,864	46,864			1	571,561	569,522	6			25,827	25,827			8	319,519
California	376,505	190,789	1		1	1,315,838	1,309,865	9	1		20,630	20,630			7	1,477,100
Colorado	5,685	5,646				590,186	590,186	6			10,955	10,955			5	556,466
Connecticut	166,222	165,415	2			61,712	60,676		1		231,374	222,740		1		351,963
Delaware						94,135	94,135	1			697,074	508,721	3	1	1	73,349
Florida	20,370	20,370			4	519,457	518,468	5		11	366,306	362,050	3		24	705,892
Georgia	368,009	368,009	5	1	1	963,435	963,435	6	6	1	971,048	971,048	3	5	27	1,133,402
Idaho	11,301	11,301				302,225	293,553	3	1		34,621	34,621	1		4	261,243
Illinois	70,841	58,755			26	2,209,791	2,002,366	9	1	51	447,513	423,669	2	1	32	1,560,359
Indiana	4,359	4,359			3	944,155	931,668	7	1	15	228,411	222,702	1		41	649,115
Iowa	77,032	73,590	1		2	1,388,262	1,134,614	11	3	9	499,481	488,245	1		71	129,155
Kansas	14,071	14,011			2	590,610	590,610	9			348,854	304,969	5		14	870,883
Kentucky	163,064	161,519	2		1	1,075,361	1,069,247	8	1		306,574	306,574	3			59,942
Louisiana						588,415	588,415	8			471,538	470,371	4		1	610,731
Maine						388,443	388,443	2			1,861	1,861			1	117,994
Maryland	464,400	432,607	2	2	2	344,709	344,709	2		6	593,303	449,505	2		14	204,759
Massachusetts						1,022,124	1,010,284	5	1		855,642	855,597	3	2		884,817
Michigan	359,700	359,700		1	4	1,000,155	1,000,155	3	3	1	525,632	495,471	2		28	599,154
Minnesota	238,051	238,051	1	3	1	1,127,961	1,127,961	8	3		252,095	252,095	1	3		693,398
Mississippi	177,900	177,900	1		1	587,874	587,874	8	1		235,900	235,900	2		11	432,668
Missouri						2,034,922	1,579,502	6	4		205,495	173,526		2		1,194,939
Montana						230,745	230,745	3			6,645	6,645			2	470,918
Nebraska	132,604	132,604		1	9	1,118,942	1,118,942	22		4	100,552	100,552	1		12	107,255
Nevada	119,580	119,580	2			56,484	56,484	2			21,703	21,703			7	103,558
New Hampshire	63,682	62,862	2			303,989	303,689	4	2		3,817	3,817			2	201,694
New Jersey	214,360	214,360	2			1,254,863	1,129,313	5	2	1	354,985	295,560	1	2		552,697
New Mexico						2,560	2,560				318,427	311,393	4		1	344,481
New York	984,228	958,002		7		2,975,236	2,926,252	5	11		701,610	662,685		2		2,563,872
North Carolina	324,980	324,980	2	1	13	313,183	313,183		6	3	169,871	166,993	1		24	889,961
North Dakota	83,460	83,460	2			697,230	684,293	8			223,120	223,120	2			331,653
Ohio	324,301	323,904	1	1	1	3,455,493	3,374,450	15		3	543,807	284,750	2		8	1,046,952
Oklahoma	121,346	117,930	1		14	766,212	762,802	5		3	502,456	444,414	4		21	1,113,391
Oregon	302,166	278,255	3		2	125,127	84,757	2			4,733	4,733			3	390,976
Pennsylvania	710,467	710,139	7			3,247,657	3,208,226	17			1,306,206	1,301,193	7			1,324,754
Rhode Island						208,896	208,896		1							176,063
South Carolina	124,756	124,756	2		6	372,732	360,332	5	3	6	314,748	178,074	1	2	19	688,745
South Dakota	341,870	341,870	10			656,402	640,452	12		5	58,043	58,043	2		4	587,095
Tennessee	92,670	83,670	1	2		1,309,479	1,309,479	8	1		93,460	93,460		1		852,311
Texas	648,990	639,990	7			1,734,475	1,726,891	17			210,900	202,450	4		5	1,351,629
Utah	41,268	40,526	2		12	72,149	72,149	1		11	67,714	67,714			24	232,778
Vermont	2,205	2,193				337,885	308,106	2		4						5,485
Virginia	32,555	32,555		1		777,750	777,290	5	4		106,935	87,435	2		5	566,936
Washington	55,443	55,443		1	1	333,418	333,418	3	1		12,151	12,151			4	451,910
West Virginia	6,320	6,320			2	811,462	805,842	9	1	4	97,130	97,130			3	505,251
Wisconsin	46,124	46,124			11	899,718	869,734	5	2	11	112,489	112,489			26	1,156,114
Wyoming	477,151	477,149	5			4,929	4,929				8,199	8,199			6	286,073
District of Columbia	2,193	2,193				1,462	1,462				298,213	273,744		1		5,493
Hawaii	192,574	192,566	2			214,170	213,655	2								179,950
Puerto Rico	103,629	102,980	1			639,340	632,516	9								337,988
TOTALS	8,116,135	7,806,136	67	21	121	41,254,347	39,825,541	295	67	151	13,157,705	12,027,977	69	24	473	30,642,917